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A Summary of Current Program and
Preliminary Report of Progress

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DAIRY RESEARCH

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United States Department of Agriculture
and cooperating agencies

C & R-PREP.

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

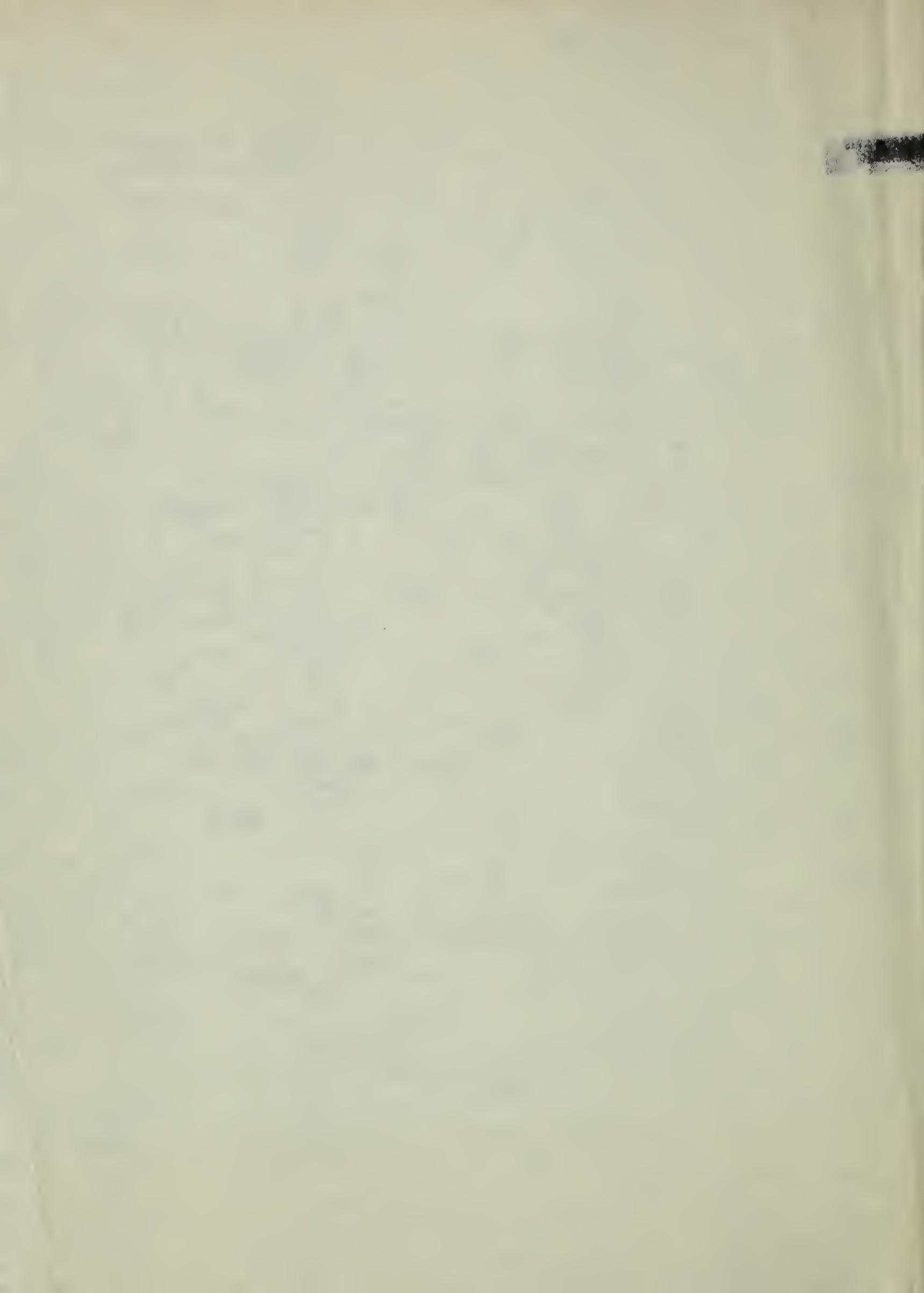
There is included under each problem area in the report, a brief and very general statement on the nature of the research being conducted by the State Agricultural Experiment Stations and the professional manpower being devoted by the State stations to such research. Also included is a brief description of related work conducted by private organizations. No details on progress of State station or industry research are included except as such work is cooperative with U.S.D.A.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the last two years. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE

Washington, D. C.
December 15, 1962



OTHER COMMODITY AND FUNCTIONAL REPORTS

A progress report similar to this one is prepared for use by each of the following research and marketing advisory committees:

Citrus and Subtropical Fruit	Sheep and Wool
Cotton and Cottonseed	Sugar
Deciduous Fruit and Tree Nut	Tobacco
Forage, Feed and Seed	Vegetable
Forestry	Economics
Grain	Farm Equipment and Structures
Livestock	Food and Nutrition
Oilseeds and Peanut	Food Distribution
Potato	Home Economics
Poultry	Soils, Water and Fertilizer
Rice	Transportation and Storage

Two additional reports of progress are prepared in order to make available the complete research program. They are:

Ornamentals and Other Miscellaneous Commodities
Other Research — Cross Commodity

ORGANIZATIONAL UNIT REPORTS

All of the material in the commodity and functional reports listed above is the same as that found in the 20 division and 3 service research reports listed below.

Agricultural Research Service (ARS)

Agricultural Engineering
Animal Disease and Parasite
Animal Husbandry
Crops
Entomology
Soil and Water Conservation
Utilization -- Eastern
Utilization -- Northern
Utilization -- Southern
Utilization -- Western
Human Nutrition
Clothing and Housing
Consumer and Food Economics

Agricultural Marketing Service (AMS)

Market Quality
Transportation & Facilities
Economic Research Service (ERS)

Farm Economics
Marketing Economics
Economic & Statistical Analysis
Foreign Development and Trade Analysis
Foreign Regional Analysis

Other Services

Farmer Cooperative Service (FCS)
Forest Service (FS)
Statistical Reporting Service (SRS)

A copy of this report or any of the others listed above may be requested from Max Hinds, Executive Secretary, Dairy Research and Marketing Advisory Committee, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

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1/ A supplement entitled "Research on Nutrition of Animals as Affected by Properties and Characteristics of Soils and Plants" which reports work done by the Soil and Water Conservation Division, ARS, is available upon request. (See bottom of opposite page.)

INTRODUCTION

Dairy research as used in this report is concerned with the production, processing, marketing, and consumption of milk and its products. The report covers Farm Research, Utilization Research, Marketing Research, Economic Research, and Consumer-Use Research of the U.S.D.A. and cooperating agencies. Only a brief description of the related work of the State Experiment Stations and industry is included.

Under each of the Problem Areas there is a statement describing the Program of work underway and the professional man-years devoted to the major kinds of research included. The relative scope of the total research effort pertaining to the dairy industry is indicated by the approximate number of professional man-years employed: 290 by U.S.D.A., 431 by the State Experiment Stations and about 1,400 by industry and other organizations.

A brief report of Progress and significant findings for U.S.D.A. and cooperative programs is given for each phase of the research program. A considerable amount of basic cross-commodity and functional research that will supply new knowledge applicable to dairy problems is not included in this report. Such research is included in the functional reports such as "Economics," "Soils, Water and Fertilizer," and in the "Other Research" report.

Research by USDA

The farm research comprises investigations of breeding, physiology, nutrition, diseases and parasites, housing and management of dairy animals, and sanitary handling and storing of milk until it leaves the farm. This research is conducted by the following divisions of Agricultural Research Service: Animal Husbandry, Animal Disease and Parasite, Agricultural Engineering and Entomology. In fiscal year 1962 this work involved 179 professional man-years.

Utilization research deals with the processing phase involving pasteurization, bottling, separation of cream and skim milk, manufacture into products such as butter, powder, cheese, concentrated forms, ice cream, and numerous specialty items. Also, it is concerned with improved equipment and processes. The work is done at the Eastern Utilization Research and Development Division, Wyndmoor, Pennsylvania, and in its other laboratories located at Beltsville, Maryland, and Washington, D. C., and under contract with State and foreign-country laboratories and in cooperation with the industry and other organizations mentioned under Program for each research area. In fiscal year 1962 the work involved 82 professional man-years.

Marketing research involves the physical and biological aspects of assembly, packaging, transporting, storing, and distribution from the time the product leaves the farm until it reaches the ultimate consumer. The work reported herein is conducted by two divisions in the Agricultural Marketing Service: Transportation and Facilities and Market Quality. In fiscal year 1962 this work involved 6 professional man-years.

Economic research is concerned with marketing costs, margins and efficiency, market potential, supply and demand, outlook and situation, and improving marketing through research with farmer cooperatives. Fundamental research contributes tools for determining elasticities of demand, statistical formulas, and other analytical guides that can be applied to different situations. The work reported herein is done by the Economic and Statistical Analysis and the Marketing Economics Research Divisions of the Economic Research Service, and by the Marketing Division of the Farmer Cooperative Service. Approximately 22 professional man-years were devoted to this work in fiscal year 1962.

Nutrition and Consumer-use research pertains to composition and nutritive value; physiological availability of nutrients and their effects; and new and improved methods of preparation, preservation, and care in homes, eating establishments and institutions. This work is done by the divisions of Human Nutrition Research, and Consumer and Food Economics Research of the Agricultural Research Service. In fiscal year 1962 this work involved approximately 2 professional man-years.

Research by State Experiment Stations

There is included under each problem area a brief and very general statement on the nature of the research being conducted by the State Agricultural Experiment Stations and the professional manpower being devoted by the State stations to such research.

Consolidating this information for the entire field of interest, we find that in fiscal year 1962 a total of 430.8 professional man-years were spent by the State Agricultural Experiment Stations on dairy research. In addition, 92.8 professional man-years were devoted to research in animal biology, many of which were oriented toward dairy.

Dairy research in 1962 was in progress in 52 of the 53 State Agricultural Experiment Stations. Studies underway were carried out by research workers in Departments of Dairy Science, Animal Science, Agricultural Economics, Agricultural Engineering, Agricultural Chemistry, Home Economics, Veterinary Medicine, Food Technology, Genetics and Entomology.

Dairy research at the State Agricultural Experiment Stations in 1962 included 46.5 man-years on breeding, 45.1 man-years on physiology, and 87.7 man-years on nutrition and management. Also included is 73.2 man-years of research on infectious and non-infectious diseases of cattle (beef and dairy), 21.7 man-years on parasites and parasitic diseases of cattle (beef and dairy), 5.7 man-years on insects common to dairy cattle, 4.3 man-years on dairy buildings and equipment, 39.5 man-years on dairy products -- chemical, physical and bacteriological characteristics, 28.1 man-years on dairy products -- development of new and improved products and processing methods, 10.3 man-years on dairy products -- market quality, 58.3 man-years on marketing economics -- market structure and practices, market costs, margins and efficiency, alternative market outlets, merchandising and promotion, marketing orders, special milk programs, evaluation of marketing information -- and other studies, 9.1 man-years to economic and statistical analysis, and .6 man-year to farmer cooperatives.

Research on the economics of production, overall research on statistical reporting, and buying decisions common to all foods, has not been broken down on a commodity basis. The same is true of the research on the nutritive value of dairy products for humans -- only .6 man-year can be identified as applicable to dairy products alone.

No details on progress of State station research are included in this report except as such work is cooperative with U.S.D.A.

Research by Industry and Other Organizations

The 1,400 professional man-years estimated for calendar year 1961 as industry's participation in dairy research are employed primarily by feed and equipment manufacturers, processors of dairy products and chemical companies. Feed manufacturers have and will continue to study rations for dairy cattle and develop and test new formulations of mixed feeds including chemical growth stimulators.

A large number of companies make application of basic research developed through public research with emphasis on products intended for prevention, control, or treatment of diseases, parasites and insects. Industry research is aimed at testing chemicals and measuring residues, however, final evaluation is often done cooperatively with public agencies. Most of the identification and classification of insects, diseases and parasites is done by public institutions.

About 1/3 of the industry research effort in the dairy industry is in the utilization field. Very little of the work is basic and where it is, the results are usually patented. In applied research

the major activities are in cost saving, container testing and low calorie product formulation. Public research was used to develop the procedure for removal of strontium-90 from milk.

Industry is showing an increasing willingness toward cooperative research with public agencies. This is well illustrated in the chemical field where increasing costs, difficulty, and the time required to secure clearance because of residue problems before a new pesticide can be used on food products make it less attractive for the private companies to work alone. Basic research by private companies is now even less attractive than before and makes increasingly evident the necessity for basic research by public agencies. The advantage of cooperative applied research between public and private agencies is well illustrated in the work with stored products insects. Here literally millions of dollars worth of produce, materials, equipment, storage space and additional manpower are made available by industry at no cost to the Department.

It has been estimated that one billion dollars per year is being expended in building new and modernizing old marketing facilities. Planning of marketing facilities that benefit handlers of commodities flowing through the marketing channels is of such magnitude and affects so many individual and community interests that its nature makes it a public activity. A small Federal staff makes an important contribution to overall market planning which is utilized by architectural and engineering firms to develop plans, drawings and specifications for specific facilities on particular sites. In contrast with facility research, industry research in the equipment field is at a man-year ratio of 350 to 1. In this research the emphasis is on new or improved items of equipment which can be patented and for which there is thought to be a ready market outlet.

The greater part of the marketing economic research in industry is conducted in connection with new product development and in merchandising and promoting farm products. In addition, industry contributes in a large way to State and Federal research programs by offering its facilities and facts to the public research agencies. Public research is used for comparison and analysis where private research does not have access to the plants and records of competitors. Industry participates heavily in consumer preference research but largely with respect to a firm's own brand name.

Examples of Recent Research Accomplishments
by USDA and Cooperating Scientists

Low moisture silage. In recent years much of the hay crop forage used for silage contained from 65 to 80% moisture when stored. Nutrient losses during storage were frequently high and feeding trials consistently showed that these high moisture silages were not equal in feeding value to hay made from the same crop. The first breakthrough pointing the way to the adoption of new techniques which would overcome these deficiencies resulted from a series of trials which showed that silage, virtually equal in feeding value to good quality hay, could be produced if the forage was stored when it contained 50 to 55% moisture rather than 65 to 80%. Nutrient losses during storage were also reduced with this type of forage.

These first experimental silages were produced in gastight silos. Further studies using conventional silos demonstrated that this improved type of silage could be successfully made in any type of silo, which may be available, provided that the silo is made airtight. Inexpensive means for adequately sealing silos have been developed.

The usefulness of these findings has been recognized rapidly by producers of livestock feed. Five years ago high moisture (haycrop) silage was predominant and production was declining because of the excessive storage losses and the shortcomings of the silage as feed. Now this trend has been completely reversed. Silage production from hay crops is increasing and low moisture silage (frequently referred to as Haylage) is becoming the predominant type.

Ventilation of livestock buildings. Research in cooperation with State Experiment Stations has obtained much needed basic data on the heat and moisture given off by cattle, hogs, and poultry, and on the influence of building environment on production and feed consumption. The heat and moisture dissipation data are considered basic design data for ventilation systems of poultry, dairy, and swine buildings. They appear in design handbooks including the 1962 Guide and Data Book of the American Society of Heating, Refrigeration, Ventilating, and Air Conditioning Engineers, and are used by makers of ventilating equipment, prefabricated buildings and package buildings as well as by specialists advising farmers on their own construction. Building improvements resulting from the above research have contributed to the substantial rise in efficiency of livestock production that has occurred during the past decade.

Pasteurizer-deodorizer. A new low-cost process that pasteurizes and deodorizes market milk at temperatures no higher than those required for pasteurization, provides improvement over existing procedures for deodorizing milk. Market milk is brought to pasteurization temperatures (161-165° F.) by steam injection, then deodorized by flash cooling in a vacuum chamber. This removes volatile feed flavors that may have been present in the milk, along with the water added as steam. Although some milk has been deodorized, the new process is more efficient and less costly than conventional processes. Some of the essential features of the new process have been adopted by a large dairy that handles 31,000 quarts of milk per hour.

Criteria for Evaluating Dairy Cooperatives. Leaders of dairy cooperatives, educational and advisory workers, and administrators of governmental programs have needed a basis for distinguishing an actual (bona fide) from an imitation (pseudo) cooperative. Research to develop standards for determining the cooperative character of individual dairy organizations provides a set of measures designed for appraisal of dairy organizations to determine whether they meet acceptable standards as cooperative organizations. It also sets forth principles of organization and operation of dairy cooperatives that should be followed by cooperatives to best serve the needs of their members. Results of this study will assist in maintaining forms of organization and policies of operation that will help farmers obtain maximum returns and stable markets.

PROGRAMS OF MARKETING SERVICE and EDUCATION

The Research and Marketing Act of 1946 authorized a number of activities in addition to research. Some of these are: "to conduct and cooperate in consumer education...to collect, tabulate, and disseminate statistics on marketing agricultural products...to develop and promulgate - procurement standards and specifications for agricultural products...to inspect, certify, and identify the class, quality, quantity and condition of agricultural products...and to conduct information programs designed to eliminate artificial barriers to free movement of agricultural products."

Part of two programs are included in this report: one a statistical service program in dairy statistics, the other an educational program in dairy marketing. Both were selected because they are closely related to research work included in the report.

The value of service, educational, and regulatory programs can be observed every day around us. The statistics are used constantly in making business decisions by persons in all segments of the dairy

industry from producers to consumers. Inspection, grading and regulatory activities insure a daily supply of wholesome milk and dairy products. A classic example of research-education-regulatory cooperation is the eradication of the screwworm in the Southeastern United States. Another pertains to a milk flavor program. Several years ago a problem of flavor in the milk served to children occurred in one of the schools in Vermont. Out of this problem a cooperative effort was put in motion involving research, education, regulation, farm groups and organizations, business groups, and consumers. This effort evolved into a State-wide program of milk flavor improvement. The program attracted interest in 35 States. Similar programs, but varying according to local needs, soon appeared in Massachusetts, Maryland, Alabama and Nebraska. Undoubtedly, a number of other States have developed similar programs.

I. FARM RESEARCH

DAIRY CATTLE - BREEDING
Animal Husbandry Division, ARS

Problem. Dairymen need information on genetic methods for increasing the efficiency of milk production and modifying milk composition, as well as other economic traits, in order to reduce unit costs and meet the future market demands. Precise information is needed on the relative importance of performance traits, the nature of their inheritance and their response to selection and specific systems of mating. Recently advanced genetic methods, such as those utilizing heterosis and specific and general combining ability, need to be evaluated as procedures for more rapid improvement of milk production or other important traits.

USDA PROGRAM

This is a continuing program conducted by geneticists on basic and applied studies of the inheritance of the dairy cow including experiments designed for evaluating the application of advanced genetic concepts to dairy cattle improvement. The work is in progress at Beltsville, Maryland, and cooperatively with 14 State experiment stations and laboratories in nine foreign countries. Several of the studies contribute to the North Central and Southern regional dairy cattle breeding projects. The work on performance testing includes cooperation with 50 States and Puerto Rico with the Records and Breeding Committees of the American Dairy Science Association. Cooperation is also carried out with the National Association of Artificial Breeders and with the various dairy cattle breed registry organizations.

The Federal scientific effort devoted to the research in this area totals 21.7 professional man-years. Of this number, 7.2 are devoted to genetics and interrelations of performance traits, 2.3 to performance testing, 11.0 to selection and systems of breeding, and 1.2 to program leadership.

A grant with the Agricultural Research Center, Tikkurila, Finland, provides for research on the breed differences regarding the antigenic properties of cattle blood, their inheritance in relation to economic characteristics and genetic origin of the breeds. Its duration is for four years, 1961-1964, and involves PL-480 funds with a \$61,804 equivalent in Finnish Finmarks.

Another grant with the Division of Investigaciones Agropecuarias, Ministry of Agriculture, Bogota, Colombia, supports work on the evaluation of the native breed, Costeno Con Cuernos, and Holsteins and Brown Swiss when mated and selected for dairy traits under the

hot and humid conditions of Northern Colombia. The duration of the grant is for five years, 1962-1967, and involves PL-480 funds with a \$246,000 equivalent in Colombian pesos.

Two PL-480 projects (also reported in area 6) S3 AH-7 at Sao Paulo, Brazil, and A7 AH-1, at Izatnagar V. P., India, are in effect and are pertinent to this area.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 46.5 professional man-years divided among sub-headings as follows: genetics and inter-relations of performance traits 25.6, performance testing 3.9, selection and systems of breeding 17.0. This research is currently being conducted by stations in all four of the regions with research in two regions being coordinated through the S-49 and NC-2 regional projects. Eleven stations and the USDA are cooperating through the S-49 regional project. Problems include development of adapted strains from crossbred foundations, measurement of heterosis and crosses of dairy strains, effective measures of heat tolerance in dairy cattle, and selection for productivity. Twelve States and the USDA are cooperating through the NC-2 regional project. The effort involves studies on systems of breeding, selection, and genetics of performance traits.

Estimates of genetic parameters in dairy cattle are being made from data collected in several States. Traits of the economic importance under consideration include milk production, persistence of production, feed efficiency, growth, dairy type, and milk composition. Projects aimed primarily at assessing the importance of environmental and genetic factors affecting the constituents in milk have recently been developed. Use is being made of identical twins and assessing genotype by environmental interactions. The inheritance of blood cell antigens is under investigation and attempts are being made to determine the relationships between the blood antigen picture and performance traits. Research on inheritance of congenital abnormalities of dairy cattle is also in progress.

Work is also currently in progress at State experiment stations to determine the effectiveness of mass selection for excellence in one or more dairy traits as compared to non-selected controls, inbred lines, and crosses of inbred lines. The use of proven sires as compared to young sires selected on pedigree information is also being evaluated. The degree of hybrid vigor, which may be expected, is being estimated in breed crosses in both dairy and dual-purpose cattle.

Industry and other organizations conduct very little research in dairy cattle breeding. One breed registry association spends approximately

one professional man-year conducting studies on the genetics and interrelations of performance traits and techniques of performance testing. The members of the National Association of Artificial Breeders collectively and individually cooperate with nearly all the breeding projects discussed under the program of the USDA by supplying semen for experimental matings. In addition, this group as well as breed associations supply support for studies on performance traits and performance testing in several State experiment stations. Private breeders often cooperate with State experiment stations and Federal agencies by providing data from their herds for use in research studies.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. The Genetics of Feed Utilization.

These studies were undertaken to determine if there are inherited differences in the ability of growing and lactating dairy cattle to utilize feed. The research is being conducted at Beltsville and in cooperation with the Agricultural Experiment Stations of Montana, Utah and Tennessee. The Tennessee study is a contributing project to the Southern Regional Dairy Cattle breeding project.

The studies at Tennessee, Montana and Utah were designed to determine the genetic variability within the Holstein and Jersey breeds in forage utilization for production and growth. Mating plans utilize sires of diverse blood lines. Half of each resulting sire group is fed on roughage only through first lactation and the other half is given a ration of roughage plus grain.

At Lewisburg, Tennessee, a total of 98 first lactation Jerseys on the forage utilization project have completed 305-day production records; 48 on roughage only, and 50 on roughage plus grain. The average mature equivalent, fat corrected milk (ME FCM) yield for the roughage group was 9,286 pounds as compared to 11,586 pounds for the roughage plus grain group. The roughage group produced 80.0% as much ME FCM as the roughage plus grain group. Six sires have enough daughters with completed records so that sire group comparisons can be made. Assuming that the daughters on roughage plus grain produced at their capacity, the daughters of these sires on roughage alone produced 79.8, 82.7, 79.3, 76.2, 77.4 and 80.9% of their capacity. The daughters of one sire when fed either roughage plus grain, or roughage alone, produced more than any of the other groups. On roughage plus grain they produced 1,435 pounds more than the nearest group, and 1,412 pounds more on roughage alone. The results of a two-way analysis of variance showed significant differences among both

sires and feeding systems in ME FCM yield. However, the sire X system interaction was not significant. This indicates that in the preliminary data high producing progeny groups on one system were also high on the other system.

A total of 42 first lactation Holstein cows, originating at Huntley, Montana, and currently at Logan, Utah, have completed production records on the forage utilization project. This number represents the daughters of four sires. The average ME FCM yield of the cows fed hay alone was 9,319 pounds as compared to 13,348 pounds for those fed roughage and grain. Assuming that the cows on roughage and grain produced at their capacity, the cows on hay alone produced 69.3% as much. On an individual sire group basis, the daughters of 1121, 3163, 3511, and 3194 produced 76.9%, 76.1%, 67.5%, and 56.9% as much respectively on hay alone as compared to those on hay, silage and grain. When fed roughage and grain, the daughters of 3511 produced more than the other groups; yet, on hay alone, the daughters of 3511 ranked third in level of production. On hay alone, the daughters of sire 3163 produced more than the other groups, ranked second in production when grain was fed. Another striking switch in production levels were the daughters of sire 1121. On hay alone, 1121 daughters ranked second in production; however the daughters who received roughage and grain produced at the lowest level of the four groups. This reversal in the ranking of the sire groups between the two levels of nutrition was not evident in the Lewisburg data. The results of a two-way analysis of variance indicated significant differences in ME FCM yield among the two groups. The difference among sires was not significant. However, the sire X system interaction approached significance.

When the Lewisburg Jerseys are compared to the Huntley Holsteins on the same feeding regime, the mean ME FCM yield is practically the same. On a percentage basis, the Huntley Holsteins on hay alone produced only 69.3% as much as their half sib pair mates on roughage and grain, as compared to 80.1% for Lewisburg Jerseys. These results would indicate that the Jerseys may be more efficient utilizers of roughage alone for milk production than Holsteins. However, additional data is necessary before this can be considered a valid observation.

The research in progress at Beltsville to determine the value of certain feeding methods in estimating genetic differences in feed efficiency among cows is being continued. At the present time 22 cows fed at a constant rate have completed 35 lactations. Their average FCM yield was 13,951 pounds with a corresponding feed efficiency of 2.001. The standard deviation of FCM yield and feed efficiency was 1,875 and 0.25, respectively. Twenty-three cows fed according to production standards have completed 38 lactations. These cows averaged 15,195 pounds of FCM and their average efficiency of feed utilization was 1.96. The standard deviation of FCM yield and feed efficiency was 2,677 and 0.18,

respectively. These results indicate the 1,244 pound greater average yield of the standard fed cows was probably due to the difference in the average energy intake among the groups. The standard fed group received an additional 800 therms of E N E. There was more variation in FCM yield among cows in the standard fed group than in the constant fed group. This would be expected when feeding according to production and maintenance requirements, as opposed to feeding a constant energy level regardless of production and maintenance requirements. The intra class correlations (repeatability) between successive lactation for FCM yield was 0.10 and 0.67 for the constant fed and standard fed groups, respectively. The repeatability of feed efficiency was 0.20 and 0.51 for the constant fed and standard fed groups, respectively. The standard fed group was more persistent and gained more weight during their lactation than the constant fed group.

To date a total of ten cows have completed lactations on a ration of ad lib grain, hay and silage. These tests were and are being continued in an effort to evaluate unlimited feed intake in relation to feed efficiency and milk production. There appears to be considerable variation in both total yield and feed efficiency among the cows in their response to full feeding. The range in FCM yield and feed efficiency was 7,343 to 18,208 and 1.24 to 2.16, respectively. The average FCM yield for the group was 13,172 pounds of milk and a standard deviation of 3,363 pounds. The average feed efficiency was 1.63 as compared to 1.67 for their first lactation; however, the standard deviation was 0.29, which was twice as large as it was during the first lactation. Four of the ten cows were by one sire and three of these milked less than 280 days; and the fourth one produced only 500 pounds more than she did in the first lactation. The remaining six cows were by three different sires. All but one of these exceeded their first lactation ME by a considerable margin on ad lib feeding. Future efforts will be made to test at least 3 - 4 daughters per sire in order to evaluate the effect of sires. These cows consumed an average of 64.3% of their total energy in grain, as compared to 33.6% in the first lactation when fed according to the usual feeding procedures. (AH gl-4)

2. Body Form and Internal Anatomy of Cows and Milk Goats

A comparative study has been made of the external body form, internal anatomy and production records of Toggenburg goats and of Holstein and Jersey cows. The data on 14 goats were obtained through cooperative arrangements with the New Mexico Experiment Station. The data on cows were obtained on 185 Holsteins and 194 Jerseys in the Beltsville herd. In age at slaughter the goats averaged 7 years 5 months, the Holsteins 6 years 11 months, and the Jerseys 7 years 1 month. The average for each item of external and internal weight or measurement in goats was expressed as a percentage of the corresponding

weights or measurements of the combined average of Holstein and Jersey cows. The goats averaged less than 10 percent of the cows in body weight. The goats were found to be tall and long, definitely narrow bodied--particularly in the region of the pelvis--and to have short, wide heads as compared to dairy cows. On the average the goats showed slightly more wedge in depth and in width than the cows. In thoracic index--the relation of depth to width of fore chest--the goats exceeded the cows. In abdominal index--the relation of depth to width of paunch--the goats exceeded the cows to an even greater extent. Slope of rump in the goats was 31.4 degrees compared with an average of 5.7 degrees in the cows. The relatively short, wide heads of the goats are indicated by the relation of length to width--which was 1.64 in the goats compared with an average of 2.20 in the cows. Legginess, the percentage of total height below the under surface of the chest, was considerably greater in the goats than in the cows.

Comparisons made on the basis of the number of units of weight or measurement of internal organs per 100 pounds empty body weight showed that the weights of brain and pituitary were relatively about 3 times as great in the goats as in the cows; reticulum, pancreas and thyroid weights and length of large intestine were about twice as great; heart, liver, kidney, pineal and adrenal weights and length of small and total intestines were relatively one-and-one half times as great. There was relatively little difference in the weights of total stomachs or blood.

The highest actual 2X, 305-day records of production were used in determining averages for both goats and cows. The average production of the goats was 1,548 pounds of milk containing 61.38 pounds of fat and testing 3.96 percent. The average for Holsteins was 12,978 pounds of milk containing 479 pounds of butterfat and testing 3.69 percent. (Since the percentage of fat in the goats' milk more nearly approximated that of Holsteins than of Jerseys the production of goats was compared with that of Holsteins).

When measured prior to slaughter the goats averaged 111.29 pounds in weight. The average for 185 Holstein cows, prior to slaughter, was 1,343 pounds. On the basis of these weights the goats produced 13,910 pounds of milk and 552 pounds of fat per 1,000 pounds body weight. On a comparable basis the production of the Holstein cows was 9,670 pounds of milk and 357 pounds of fat. (AH gl-1)

3. Body Form of Holsteins and Jerseys at Different Periods of Life.

In studies of the growth and body form of animals in the dairy herd at Beltsville 28 body dimensions were measured and various body proportions were determined. Marked differences in variability in the dimensions have been shown. Variability was found to be lowest for

body heights and next lowest for body depths. The highest variability was for body widths. Among the body proportions studied legginess showed the lowest variability, followed by wedge based on depths and wedge based on circumferences. Aside from a higher variability at 3 months there was little change with age in variability for the various groups of dimensions or for the body proportions mentioned.

Although variability in most measurements remained nearly the same during life, some of the body proportions themselves underwent substantial changes, that is, the animal did not grow symmetrically. Average results for Holsteins and Jerseys show that height at withers was 3.3 percent less than height at hips at 3 and 9 months, 2.4% less at 12 and 18 months, and 0.6% less at first and second lactations, but 0.3% greater at maturity. A much greater change occurred in the relation of body length (withers to pinbones) to height at withers. Body length averaged 15.1% less than height at 3 months, 7.5% less at 6 and 9 months, and 2.8% less at 12 and 18 months. At first and second lactations, however, body length was 3.0 percent greater than height at withers, and at maturity it exceeded wither height by 6.3%. A marked change was found to occur also in the relation of hip width to thurl width. Width of hips was 11.1% less than width at thurls at 3 months, 4.0% less at 6 and 9 months, and 2.6% less at 12 and 18 months. Hip width, however, was 11.4% greater than thurl width in first and second lactations and 13.0% greater at maturity. The change from a lower to a higher relative width for hips occurred at a younger age in Jerseys than in Holsteins. The ratio of head length to head width (at forehead) increased progressively from 1.41 at 3 months to 1.85 at maturity, while the ratio of head length to body length (withers to pinbones) decreased progressively from .412 to .367. The ratio of depth to width of chest averaged 1.85 at 3 months and 1.74 at 6 months. It remained at approximately 1.68 to 1.70 at later ages. Ratios of depth to width of paunch, however, declined progressively from 1.32 at 3 months to 1.08 at maturity.

Further evidence that animals do not grow symmetrically is brought out by differences in percentages of maturity at 3 months of age for various groups of dimensions. For Holstein and Jersey females the average percentages were 66.9 for heights, 62.3 for head measurements, 53.0 for body lengths, 51.0 for body depths, 49.4 for body circumferences, 44.0 for pelvic widths and 43.8 for widths of the barrel (chest and paunch). Breed differences in these percentages were small except for widths and circumferences of the barrel which were considerably higher for Holsteins than for Jerseys. (AH gl-1)

4. Body Measurements of Holstein and Jersey Cows and their Records of Milk Production.

Determinations have been made of the relationships between body measurements recorded during both first and mature lactations and

records of production. Simple correlations were determined between each measurement recorded during first lactation and both the first lactation M.E. and the highest production, and also between each measurement obtained at maturity and the highest M.E. production. The analyses involving first lactation measurements included 478 Holstein and 343 Jersey cows; those involving mature lactation measurements included 211 Holstein and 162 Jersey cows. Partial correlations, independent of live weight, also were determined for many of the 28 items of measurement to show the extent to which the more significant associations indicated by the simple correlations would hold if the effects of body weight (size) were eliminated. In almost every instance with Holsteins the partial correlations were lower in magnitude than the simple correlations, changed from positive to negative, or became more highly negative. The first lactation measurements having the highest association with first lactation M.E. milk production were depth of paunch (0.343), depth of rear chest (0.338), circumference of paunch (0.276) and head length (0.246). Partial correlations for these items were 0.313, 0.316, 0.217 and 0.179, respectively. Between first lactation measurements and highest M.E. production the same items of measurement showed the highest correlations and the correlations were similar to the others in magnitude. For most items the associations between mature lactation measurements and highest M.E. production were lower than those based on first lactation measurements. One exception was head length which had the highest correlation (0.285) followed by depth of rear chest (0.256), depth of paunch (0.228) and depth of fore chest (0.197). Corresponding partial correlations were 0.233, 0.228, 0.154, and 0.113. It appears that at least a portion of the associations between body dimensions and production in the Holsteins was the result of greater body size (weight).

Associations were lower in nearly all cases for Jerseys than for Holsteins. About half of the correlations were negative. The first lactation measurement having the highest association with production was height at withers (0.125 for first lactation M.E., and 0.122 for highest M.E. production). Head length ranked second with correlations of 0.114 and 0.101. Among associations of mature lactation measurements with highest M.E. production, head length was highest (0.199). In Jerseys the partial correlations tended to be relatively higher instead of lower than the simple correlations as was the case in Holsteins. However, the magnitude of the correlations in Jerseys was too low in most cases to be considered important. (AH gl-1)

5. Milk Production as Related to External Body Measurements and the Weights and Measurements of the Internal Organs.

One hundred and eighty five Holstein and 194 Jersey cows from the Beltsville herd were included in these body form-internal anatomy-production studies. Since this represents different samples of the herd than those used in correlating mature measurements in the body

form-production studies, and since the measurements were obtained at a different time, it was not expected that the results would be the same. The five highest simple correlations between milk production and individual body measurements in Holsteins ranged from 0.352 for length, withers to hips to 0.275 for depth of paunch and included length, withers to pinbones (0.329), depth rear chest (0.276). In Jerseys the simple correlations ranged from 0.250 for head length to 0.197 for length, withers to pinbones. Included in this range were length of loin (0.249), height at withers (0.229) and length withers to hips (0.223). The magnitude of the simple correlations was considerably higher than those obtained in the similar study of body form-production relationship. This was particularly the case in Jerseys. Although as in the other analysis, the partial correlations, independent of live weight, tended to be lower than the simple correlations in Holsteins and higher than the simple correlations in Jerseys, the differences were less marked. The correlations between milk production and body measurements appear to have been only slightly affected by live weight.

Greater consistency in results is shown in the relationship between milk production and the weights of the internal organs (including blood) and length of intestinal tract. The simple correlations tended to be higher in magnitude than those for body measurements, especially in Jerseys. The seven highest positive correlations ranged from 0.402 for length of total intestine to 0.260 for weight of pituitary in Holsteins, and from 0.449 for blood weight to 0.192 for lung weight in Jerseys. Six of the seven items having the highest positive simple correlations were the same in both breeds. In the order of the highest rank for both breeds these items were: weight of blood, length of total intestine, and the weights of liver, kidneys, total stomachs and lungs. Although separate correlations were determined for each of the 4 divisions of the stomach and for small and large intestine only the totals were considered in listing the highest correlations. As in the case of external body measurements the partial correlations, independent of live weight, were slightly lower than the simple correlations in Holsteins and tended to be relatively higher in Jerseys. Associations indicated by the simple correlations for the items of both external form and internal anatomy appear to be largely independent of live weight. (AH gl-2 and gl-3)

6. Genetic and Phenotypic Relations Between Production, Udder Palpations and Body Measurements.

An investigation during the past year has included the analysis of the genetic and phenotypic correlations between production, udder palpation, and body measurements at Ohio.

The genetic correlations were computed from within-herd and sire correlations of 447 daughter's traits with their dam's traits. Phenotypic correlations were computed on a within-herd basis.

Analyses indicated a few significant phenotypic correlations between production and other traits. The traits having significant phenotypic correlations were gland width and gland grade with milk and fat production (.174, .170, .138 and .135), 5-month body weight with milk production (.113), and 3-month after calving body length with fat production (.118). Genetic correlations were, in general, low in magnitude for udder palpation and 6 months measurements. Genetic correlations between production and yearling measurements were in general higher than those involving 3-month. After calving measurements, however, the 3 months A. C. height at withers gave the largest genetic correlations (.419 and .354).

Genetic and phenotypic correlations between measurements taken at the same time and at different times were of rather high magnitude. (The phenotypic correlations ranged from .252 to .770 and the values for genetic correlations, excluding six month's measurements, ranged from -.807 to 1.235).

The heritability estimates for the various traits studied ranged from zero, for most 6-month's measurements, to .57 for gland stage. The estimates for body measurements at 6 months were very low (the values ranged from zero to .10), values were low to moderate for yearling measurements (.09 to .36), and moderate to high for measurements on lactating cows (.24 to .52). The heritability estimates for udder palpation measurements ranged from .29 to .57. Estimates of heritability for milk and butterfat were .33 and .32.

A second study was completed to determine the effectiveness of using udder palpation information as an early indication of a sire's proof. When a sire's predicted proof (predicted by using the index in the Inter-regional palpation bulletin) was correlated with his actual proof, there was very little gain in accuracy realized by adding palpation data. It was concluded, therefore, that udder palpation measurements did not effectively differentiate between the capabilities of sires to transmit production traits. (AH gl-1 and gl-3)

7. Meat Production from Beef, Dual Purpose and Dairy Steers.

This study was initiated in cooperation with the Beef Cattle Research Branch to determine the relative merits of various breeds of cattle and different management systems in the production of meat. Angus, Milking Shorthorn, Holstein and Jersey calves were used and comparisons made on total gain, daily rate of gain, feed efficiency, economy of gain and quality of beef produced.

Sixteen animals of each breed were divided at random into two treatment groups from birth to 6 months of age. Treatment A was fed for maximum gains by feeding up to 40 pounds of whole milk daily and a

fattening ration free choice until 180 days of age. Treatment B was fed whole milk for 7 days and then changed to a milk replacer until two months of age. From 7 days of age until 180 days of age a maximum of 3.0 pounds of calf grain was fed per day in addition to all the alfalfa and timothy hay they would consume.

At 180 days of age 1/4 of each breed group, except Jerseys, (2 from treatment A and 2 from treatment B) were slaughtered for carcass evaluation studies. The following results pertain only to the slaughtered animals.

In both treatment groups the average 180 days weights were highest for Holsteins, followed by the Milking Shorthorns and then Angus. The average daily rate of gain followed a similar pattern.

Live animal grade prior to slaughter favored the Angus and Milking Shorthorns as compared to the Holstein. A similar pattern was found on the carcass grades.

The dressing percentages (based on hot carcass weight) in the treatment A calves ~~were~~ 61%, 60% and 50% for Milking Shorthorns, Angus and Holsteins, respectively. On treatment B the dressing percentage was 48%, 48% and 44% for the Holsteins, Milking Shorthorns and Angus, respectively. In order to evaluate tenderness, the Warner-Bratzler shear test was used. On treatment A the Angus were most tender, followed by Milking Shorthorns and Holsteins. In the treatment B group the Holsteins were the most tender, followed by the Angus and the Milking Shorthorns.

The difference between the treatment groups for each breed can possibly be attributed to the level of nutrition received. Group A calves consumed nearly 3 times as much total energy during the 180 day period than the Group B calves. The Group B calves on the average did not consume enough total energy to maintain what would be considered as a normal growth pattern.

The treatment B calves of the 1st phase of the experiment (birth to 6 months of age) for all breeds were more efficient (on each of the feeding regimes) than the treatment A calves. All calves of the first phase fed hay only during the 300 days of the 2nd phase were more efficient than the calves fed fattening ration in all the breeds except the Milking Shorthorns. There was no apparent difference in the relative level of efficiency among breeds for steers fed hay only. However, for those steers fed fattening ration only, the Milking Shorthorns were more efficient than the other breeds. Economy of gain followed a similar pattern among each of the breed groups.

On a breed group basis, these results indicate that Holstein steers fed hay only have outgained all the other breeds; followed by the Milking

Shorthorns, Jerseys and Angus. However, the Milking Shorthorn steers seem to have a slight edge over the Holsteins when fed a fattening ration and the Angus are somewhat better than the Jerseys. However, on hay only, the Angus steers are gaining less than 1 lb./day, whereas the Jerseys are gaining over 1 lb./day.

Final slaughter weights for the steers on this project are 1,200 pounds, 1,150 pounds, 1,000 pounds, and 900 pounds for the Holsteins, Milking Shorthorns, Angus, and Jerseys, respectively. To date a total of 10 steers have been slaughtered, 5 Holsteins, 4 Milking Shorthorns, and 1 Angus. The average number of days fed on the 2nd phase of the experiment was 411, 421, and 508 for the Holsteins, Milking Shorthorns and Angus, respectively. The average total gain and daily rate of gain was 715 and 1.74, 812 and 1.93, and 644 and 1.39 for Holsteins, Milking Shorthorns, and Angus, respectively.

The average slaughter and carcass grade for the 5 Holstein steers was medium. Their dressing percentage averaged 57%. The 4 Milking Shorthorns graded high medium with a 59.8% dressing percentage. (AH d3-16). (This work is also reported in Area 4, Beef Cattle - Nutrition and Management, and in Area 20, Production Influences on Animal Products).

8. Genetics of Milk Constituents

The purpose of this work is to study the genetic and non-genetic influences which affect the production of solids-not-fat, protein and other constituents in milk of individual cows. Cooperative efforts are continuing in organizing this work on a national basis. Projects have been formalized in many of the States and many of these have been incorporated into the regional dairy cattle breeding projects. A recent report indicates that there are 13,270 Holstein cows in the SNF testing program. However, only 900 of them are in the Northeastern region and only 5,000 are being tested for protein. The approximate numbers available for the other breeds are: Guernseys, 2,900 SNF and 1,650 protein; Jerseys, 3,600 and 1,500; Ayrshires, 390 and 320 and Brown Swiss 750 and 450. It is estimated that 6,000 cows per breed per year for five years are needed to adequately determine genetic relationships. The program needs to be expanded if there is to be any hope of getting reliable information on breeds other than Holstein. As the cooperation develops an increasingly important problem of obtaining support for assembly and analysis of the data faces the committee which is attempting to coordinate this work. There is a rapidly developing interest by the dairy industry in the possibility of evaluating milk on the basis of protein or some other constituent rather than fat alone.

At Beltsville the program of monthly testing for protein which began June, 1960, is continuing using the Orange G dye-binding method. Various modifications of the test have been studied. The time-consuming filtration step has been eliminated by adding carbon tetrachloride

to the milk and dye reagent. This dissolves the fat and eliminates a fatty deposit on the surface of the solution which had to be removed by filtration. A study of 28 split samples indicated that the addition of 2 ml of CCI 4 does not cause a significant increase in the Optical Density reading of the sample. However, the resultant average decrease in the protein percentage is 0.14. Therefore, if CCI 4 is used, a correction should be made or the standard curve relating grams of dye bound (Optical Density reading) and Kjeldahl protein should be established with samples containing the CCl₄. Also, the need for a mechanical shaker has been eliminated. A study of 60 split samples failed to indicate a difference between samples shaken for 10 minutes on a mechanical shaker as compared with those shaken for approximately 30 seconds and allowed to stand for 30 minutes.

Seventy-three cows have completed lactations in which their milk was tested for fat, SNF and protein. They averaged 15,902 pounds milk, 4.13% fat, 656 pounds of fat, 8.91% SNF, 1,416 pounds SNF, 3.20% protein and 508 pounds protein (2X 305 ME). Sixty-four of these cows were Holsteins, eight were Ayrshire-Holstein crossbreds and one was a Brown Swiss-Holstein crossbred. The following correlations were calculated on the basis of lactation averages: % Fat and % SNF 0.53, % Fat and % Protein 0.33, and % Protein and % SNF 0.48. The correlation between protein and SNF is lower than expected in comparison with other reports.

A summarization of 276 lactation records on Holstein cows whose milk was tested for fat and solids-not-fat has been made. The within-sire correlation between percent fat and percent solids-not-fat was 0.49. The 276 records averaged $8.85 \pm .28\%$ SNF and $3.91 \pm .36\%$ BF. Daughters of 17 sires were included in this preliminary analysis. The sire group with the highest average SNF percent contained 14 cows (26 records) with an average of 9.11% SNF and 4.06% BF. The lowest was a group containing 19 cows (30 records) that averaged 8.56% SNF with 3.84% BF. A breakdown of records by month of calving indicated that cows calving from October through April produced more milk, fat and SNF on the average than cows calving in the May to September period. Percent fat and SNF were lower from October through April than during the other period.

At Michigan, the accuracy of the Golding plastic bead method has been tested under field conditions with DHIA supervisors doing the testing. Samples from a total of 42 cows were tested by seven DHIA supervisors. Aliquots of the same samples were tested by a laboratory technician using both the Watson and Golding methods. For the plastic bead method the average differences between duplicates in the field, between duplicates in the laboratory, and between the average of duplicates in the field and the average of duplicates in the laboratory were .07, .14 and .16% SNF, respectively. In all but one case the laboratory

results were higher in percent SNF. The within-tester correlations between plastic bead determinations in the field and the laboratory, between duplicate measurements in the field, and between duplicate measurements in the laboratory were .86, .91, and .86, respectively. The correlations between SNF percentages calculated from bead determinations in the field and lactometer determinations in the laboratory between the bead determinations in the laboratory and lactometer determinations, and between duplicate lactometer measurements in the laboratory were .94, .95 and .98, respectively. These results indicate that the Golding plastic bead method is suitable for field use.

At Wisconsin the solids-not-fat content for 325 lactations was studied to determine the effect of season of freshening, parity, sires and cows on variations in this trait. Although lactation solids-not-fat content varied significantly with the month of first test, seasonal trends were not evident. Records of first, second and third lactations were classified by sire and parity. Both sires and parity were significant sources of variation, but no interaction was found between the two. The means for the three parities were 8.81, 8.78, and 8.68% SNF, respectively. After adjustment for parity, 77 cows by 19 sires were available for estimating repeatability and heritability. The estimates were 0.82 and 0.36, respectively.

Cooperation with the Eastern Utilization Research and Development Division in studies of milk proteins is continuing. Recently, a heterogeneity of alpha casein was discovered which has not been described previously. Furthermore, the heterogeneity appears to be genetically controlled. Starch-gel-urea-electrophoresis reveals two alpha bands in the casein from some individual cows. The variants are referred to as alpha-A and alpha-B in order of decreasing electrophoretic mobility. Most individual milks contain alpha-B casein. Milk samples from 6 of 135 cows in the Beltsville herds show both the alpha-A and alpha-B bands. These six are paternal half sisters. Seven other daughters of the same Holstein bull in the Beltsville herd had only alpha-B casein in their milk. Milk from 80 other daughters of this same bull was studied along with milk from the dams of 30 of these daughters. Forty-three of the daughters had alpha-A/B casein as opposed to alpha-B in the others. One dam had alpha A/B and the other 29 had alpha-B. Thirteen daughters of the alpha-B dams had alpha-B casein while 16 had alpha-A/B. The one alpha-A/B dam had an alpha-A/B daughter. It appears most likely that these variants are determined by a pair of codominant alleles or that the alpha-A is determined by a low frequency dominant gene. Additional data is being collected to elucidate the genetics of this polymorphism. An interesting aspect of this work is that the bull that has been found to transmit the alpha-A casein is also a carrier of the congenital metabolic disease porphyria. Porphyria is reported to be caused by a recessive gene and studies are being made to determine if there is any genetic linkage between the porphyria condition and the alpha-A casein. Milk samples

from six cows affected with porphyria were examined but none had the alpha-A casein. This indicates that very close linkage of the genes or pleiotropy are not involved but studies of other porphyric animals and daughters of porphyria carrier bulls are continuing. It is still a possibility that the test for alpha-A casein may be useful in detecting porphyria carriers. (AH gl-5)

9. Immunogenetic Studies of Semen.

Sperm and seminal plasma are known to contain antigens but whether or not these vary, either within or between individuals, is not known. If genetically controlled variation exists for sperm antigens, as it does for red blood cells, it may be possible to select types of sperm, by serological methods, for use in artificial insemination. Studies of bovine semen antigens have been initiated at Beltsville. Two steers, one cow, and eight rabbits were immunized with semen from one of two bulls. Difficulties encountered previously in producing antibodies in cattle against bull semen were eliminated by mixing complete Freund adjuvant with the semen used for injection. This adjuvant is a mixture of mineral oil, lanolin and killed Mycobacterium butyricum which enhances the antibody response. Agar-gel diffusion studies confirmed the finding of several antigenic components in bull semen by Michigan workers. Analyses of the antisera against the semen of the two bulls is being made in an attempt to detect differences. (AH gl-7)

10. The Genetics of Blood Antigens in Dairy Cattle.

This work was undertaken to help coordinate and to study activities of blood antigen laboratories in this country and others in regard to repeatability of blood typing tests and comparison of reagents. Blood samples from 40 animals are sent out annually from Beltsville for concurrent analysis by blood antigen laboratories in California, Ohio, Wisconsin, Norway, Sweden, Denmark, Holland, Germany (Gottingen and Munich), South Africa, Finland, Belgium and France. The eighth trial in this program was held in January, 1962. Thirteen laboratories participated.

Studies on blood antigen characteristics were made on the Ohio NC-2 project cattle. Approximately 700 animals representing 22 different sires were studied for differences in birth weight, rate of growth, milk production, fat production, maturity index, weight of first calf and **reproductive** performance between the heterozygote for the A Locus and the other genotype. An estimate of differences indicated better production for animals heterozygous for the A group by 464 pounds of milk and 10 pounds of butterfat. The other traits tested were not significantly different. When the analysis was repeated on an intra-herd basis, these differences disappeared and showed no advantage for heterozygous A animals.

The Ohio laboratory is continuing the blood typing of cattle in the NC-2 breeding project. Approximately 1,000 animals were blood typed in 1961. A study was made of the application of elution techniques in the preparation of blood typing reagents. The general procedure in producing blood typing reagents has been to absorb antibodies from an antiserum containing different kinds leaving antibodies for only one antigenic factor. Red blood cells with appropriate antigenic factors are used for the absorptions. The practice has been to discard these cells and the antibodies they absorb. A heat elution method has been used to recover antibodies from the absorbing cells. These antibodies are then available for reagents. Eighteen eluates were prepared from three heteroimmune and six isoimmune sera. Results indicate that considerable antibody can be recovered by this technique. Maintaining the heat at 56° C. during centrifugation was found to be important in recovering antibodies by this process. Three reagents prepared from the eluates were used in standard blood typing tests and the results indicate that the type of reagent can be as reliable as those developed in the conventional manner.

Blood typing of the cattle in the Beltsville breeding herds is continuing. To date, 258 animals from the commercial crossbreeding herd and 361 animals from the Holstein experimental herd have been blood typed.

In the Finland PL 480 project 14 antisera have been produced for use as blood typing reagents. Immunogenetic studies are being made on progeny and other relatives of a bull whose calves were often hairless and born following a prolonged gestation. Indications are that this is a recessive lethal factor and not closely associated with any of the blood group genes studied. However, it is possible that the blood factor L' in the C-system is associated with the lethal and data are being collected for further study. (AH g1-6) (PL 480 E8-AH-1)

B. Performance Testing

1. Sire Proving Program.

The process of converting the manual punch card system of handling data and the compilation involved in the sire proving work to an automatic data process (ADP) 705-III system has been completed. Subsequent to this conversion, a complete reassortment of all dairy performance records on file was accomplished to enable sire proving to be based on a daughter-herdmate comparison rather than the daughter-dam comparison previously used. This action was taken for the purpose of increasing the efficiency of sire evaluation and conformed to recommendations of leaders of the industry assembled in a work conference to consider this problem.

The ADP sire-proving procedures were operated in July and August. In

this operation, incoming current lactation reports, as well as records in the Master File were given an extensive audit to bring the data to be used in sire proving to a high standard of completeness and accuracy. After the audit, there remained more than 6,000,000 records in the Master File. Approximately 600,000 were "pulled" from the Master File for correction, reconciliation or discard. A summary was made of the 10,095 proved-sire records of sires proved or reproved showing that 4,472 of the sires maintained or increased milk production in the herds in which they were used. A total of 5,267 or 52 percent of the sires had daughters averaging more than 11,500 pounds of milk. Also, 701 or 7 percent had daughters averaging more than 14,500 pounds of milk. Collectively, the sire records included 190,354 dam-and-daughter comparisons. The average of all the dams was 11,535 pounds of milk and 436 pounds of butterfat. The daughters averaged 11,377 pounds of milk and 437 pounds of butterfat. Data included in the proved-sire records were dam-and-daughter comparisons, daughter-herdmate comparisons and daughter-herd-average comparisons. Copies of the proved-sire and daughter-average records were sent to the State Agricultural Colleges for distribution to herd owners.

Special AI tabulations were compiled of the records of 7,618 sires used in AI studs since 1939. These tabulations give a statistical history of the AI program in this country in addition to showing the daughter averages of sires by States, and level of production. The tabulations included the records of 461,110 daughters having a total of 907,581 lactation records. These daughters averaged 9,637 pounds of milk and 404 pounds of butterfat. These tabulations were basically "working tool" material. They were printed and distributed to State Extension Dairymen and AI stud managers only. (AH i4-1)

2. Dairy Recordkeeping Programs.

Participation in the dairy recordkeeping plans of the National Cooperative Dairy Herd Improvement Program continued to increase during the year. The number of cows and herds included in the program is as follows:

<u>Plans</u>	<u>Herds</u>	<u>Cows</u>
Standard DHIA	42,034	1,958,355
Owner-Sampler	24,954	698,302
Weigh-a-Day-a-Month	<u>1,936</u>	<u>70,617</u>
Total	68,924	2,727,274

More herds and cows are in the overall recordkeeping program than ever before. The 1,395 dairy herd improvement associations employing 2,448 supervisors (testers) provide the organizational machinery for operating the program in the various States. Some 20 States now have State-wide

DHIA Cooperatives. Encouragement is given the other States to organize State DHIA's, so that the dairymen themselves may have a greater and greater part in the actual operation of the program at the State level. For the last several years, all States have been encouraged and assisted in converting their manual method of calculation of month-to-month records to automated procedures using electronic data processing equipment. Ten State or Regional DHIA Computing Centers are now in operation. ADP recordkeeping is now available to DHIA members in every State. Some ADP recordkeeping is being conducted in every State with the exception of Hawaii.

The Artificial Insemination Program (AI) through which the superior sires discovered and developed in DHIA herds are utilized, continued to grow during the year. During 1961, 863,781 herds were enrolled in the program. During 1961, 7,482,740 cows were bred artificially. This represents 39% of the nation's dairy cows of breeding age.

On January 1, 1961, there were 2,486 sires in 56 AI studs. Of this number, 488 or 19.6% were proved during 1961, using records of AB progeny only. The 488 sires were mated to 47,577 dams averaging 11,181 pounds of milk and 445 pounds of butterfat. Their progeny averaged 11,172 pounds of milk and 452 pounds of butterfat. (AH i4-2)

3. DHIA Record Analyses.

For the first time, the yearly DHIA herd records were compiled and analyzed using ADP-705-III procedures. The resulting tabulations were the most complete and extensive ever produced. The use of ADP procedures emphasized more than ever before the necessity for complete yearly reports free from errors, omissions and discrepancies. As these tabulations are valuable to the various States in their general dairy extension programs, it is expected that greater effort will be exerted in future years to have the yearly herd records reported more completely and accurately. A summary of the herd records based on 1,280,789 cow-year records showed that average production of DHIA cows for the record year 1960-61 was 10,796 pounds of milk and 418 pounds of butterfat. This is the highest yearly average to date by DHIA cows.

Copies of the State and national summaries of DHIA yearly herd records are furnished the State Extension Dairyman in each State and general summary information is published for general distribution in the Dairy-Herd-Improvement Letter. (AH i4-3)

C. Selection and Systems of Breeding

1. Comparisons of Inbreeding and Outbreeding.

This research was undertaken to determine the effects of inbreeding, outbreeding and interline crossing on production and other

economic characteristics of dairy cattle. It is conducted cooperatively with the Wisconsin Agricultural Experiment Station and is a contributing study to the North Central Regional Dairy Cattle Breeding Project.

The development of six inbred lines of Holstein-Friesian cattle, crosses between the lines and maintenance of controls have been continued. Studies of the effect of system of mating on the growth of animals in the six lines were made. Body weights and measurements were taken at 3, 6, 12 and 18 months and 3 months after first and second calvings. The measurements taken were body weight, height at withers, length of withers to pins and width at hips. Contemporary comparisons were made between the Ox group (outbred daughters of outbred foundation dams and sires) and the Ix <.28 (Inbreds) and also between the Cx group (outbred descendants of Ox females and by A. I. sires) and the Ix > .29, two-way linecross and three-way linecross females. The differences between the inbreds and their contemporaries are large at young ages and tend to decrease as animals get older. The intensely inbred females are more different from their contemporaries than are the less intensely inbred group. The two- and three-way linecrosses are approximately equal to their outbred controls.

The variation in weight and body measurements of the project animals was investigated. Data on 559 single births were available for the study. These calves were produced under five systems of mating (0-0, I-0, I-I, 2Lx, 3Lx) and represented six sire lines. Dependent variables included: weight, depth of chest, heart girth, width at hips, length from poll to muzzle, width at eyes, shinbone circumference, and length of gestation. A model was fitted to estimate the influence of mating system, sire line, system line interaction, sex, parity, season and year-period. Results indicate the system-line interaction was a significant source of variation in all measurements and gestation period. The main effects except for year-period were significant in most cases. However, system of mating showed no effect on length of gestation, depth of chest, width at eyes, and circumference of shinbone.

Line crosses and inbreds. A simple model which provided a measure of interaction among sire and dam lines was used for the data on body measurements of 93 to 219 females at birth, 6, 12, and 18 months of age, and after first calving. The females consisted of inbreds from inbred dams and outbreds from inbred dams. A significant interaction was found in most cases and indicated that differences between mating systems (inbreeding and linecrossing) varied from line to line. Further analyses were made using a more complicated model for independent estimates of heterosis, line-inbreeding effects, general combinability and maternal effects. Estimates of heterosis (differences between inbreds and linecrosses) were highly significant with few exceptions. There also were significant differences among the inbred lines. However, general combinability effects and maternal effects failed to show significance in most measurements at the different ages.

Linear regression estimates of inbreeding effects. Inbreeding effects on body measurements were also studied by linear regression. At different ages there were available 174 to 329 animals which were outbreds and inbreds from outbred dams (O-O and I-O) and inbreds from inbred dams (I-I). At birth inbreeding of calf showed heterogeneous effects among lines in chest depth, width at hips, poll to muzzle, width at eyes and gestation length. Calves were 2.4 pounds less in weight and 0.6 cm. less in heart girth for each increase of 10% inbreeding. Inbreeding of dam had significant effects on those measurements on which inbreeding of calf showed heterogeneous effects among lines. There was a 0.1 to 0.3 cm. increase in these measurements for each increase of 10% inbreeding of dam. No interaction between line and inbreeding of dam was observed.

Both inbreeding of calf and dam showed significant effects on most body measurements at 3 and 6 months of age. The former had a depression effect and the latter caused an increase. For body weight at 3 months there were 7.6 pounds decline and 7.4 pounds increase for each increase of 10% inbreeding of calf and dam, respectively, while variations among lines were held constant. For 6-month weight the corresponding changes were -14.1 and +9.0 pounds, respectively.

At 12 and 18 months of age and after first calving the effects of individual's inbreeding coefficient were heterogeneous among lines in most tests. Thus no general effect of inbreeding can be stated for various body measurements at these ages. (AH g2-5)

2. The Relative Importance of General and Specific Combining Ability in Relation to Breeding Dairy Cattle.

These studies were undertaken to determine the relative importance of general and specific combining ability between lines of dairy cattle within the same breed. They are designed to study the genetic methods needed for utilizing the nonadditive genetic variability which may be present in the economic characteristics of dairy cattle production. Projects are cooperative with the Minnesota and Ohio Agricultural Experiment Stations and are contributing projects to the North Central Regional Dairy Cattle Breeding Project.

At Minnesota the line development program with the Holstein herds at Crookston, Morris, and Rosemount were evaluated by computing the average relationship between pairs of milking linemates in both lines. Results indicate that the line development process is in its very early stages. The relationship between pairs of animals in the different herds making up one of the lines is less than 2%. The Crookston herd was brought into the line breeding program later than were the other two herds which partially accounts for the low relationship between animals at Crookston and Morris. At Rosemount the breeding during the past year has been almost exclusively to one sire and to

a son of this sire. These bulls are related to most of the young cows and heifers in the herd, hence the degree of relationship and of inbreeding should increase rather rapidly.

At Ohio the line development program has progressed to a point where the majority of animals in four different herds and lines are 25% or more related to each other. In addition to continuation of the lines a systematic scheme of line crossing has been initiated. Four lines are being crossed in all possible combinations with each other.
(AH g2-22)

3. Usefulness of Heterosis Resulting from Interbreed Matings.

These studies are concerned with the theoretical and practical aspects of heterosis resulting from interbreed matings. Projects are in progress at Beltsville and cooperatively with the Illinois and Indiana Agricultural Experiment Stations. The cooperating projects contribute to the North Central Regional Dairy Cattle Breeding Project. Most of the semen services are supplied through cooperation of the National Association of Artificial Breeders.

In both the Illinois and Indiana projects the viability of crossbreds has been significantly greater than that of the purebreds. In the Illinois project the number of first and second generation purebreds leaving the herd for natural causes before producing a calf averaged 20.1% versus 8.3% for the Holstein-Guernsey crossbreds. There was no difference between first generation purebreds and crossbreds in services per conception, interval from first service to conception, interval from calving to first heat and interval from calving to first service.

Analysis of production records in the Indiana experiment showed that breed of dam, breed of sire and the interaction of breed of sire by breed of dam had a significant effect on total milk yield. This indicates that crossbreeding has a significant effect on total milk production. Sire within breed also had a significant effect on total milk production but the effect of dam was not significant. Preliminary studies of persistency of milk production in this project indicates persistency was more related to the level of production than system of breeding.

A preliminary analysis of daily gains and feed efficiency of purebreds (Red Danes, Red Polls and Milking Shorthorns) and two- and three-breed crossbred steers in the Indiana project indicated that three-breed crosses grew the fastest and utilized feed most efficiently. The average daily gains were 2.02, 2.12 and 2.22 pounds for purebreds, two-breeds and three-breeds steers, respectively. In a study of feed usage by the steers for daily gain and efficiency values in successive two week periods starting at 500 pounds, total feed consumption reached

a peak at about 16 weeks past the 500 pounds or at a weight of about 750 pounds, but average daily gain and gross efficiency declined after four weeks.

At Beltsville an analysis of the performance of the foundation Ayrshire, Brown Swiss and Holstein cattle in the crossbreeding study showed that persistency of milk production of the Ayrshires and Holsteins was similar and the same was true for body weight gain and pounds of FCM produced per therm of estimated net energy consumed. The Brown Swiss were significantly higher in persistency and body weight gain but significantly lower in gross efficiency. Studies of the rate of milking on the foundation cows between the second and eighth month of first lactation showed that the best estimate of the characteristic rate of milk flow can be obtained between the 90th and 120th day of lactation. Repeatability estimates for rate of milk flow (lb./min.) was high (.78) while that for average stripping time and percent of yield in stripping was considerably lower (0.48 - 0.49). The Brown Swiss were slightly lower in rate of milking and had significantly higher stripping time and percent of yield in stripping. Thus far, the average body weights at birth, 6, 12, 18 and 24 months of age for first generation crossbreds has been higher than for the average of all purebreds, but differences were not significant except at 12 months. The crossbreds have also exceeded the purebreds in depth and circumference of fore-chest, but slightly less in body length. (AH g2-23)

4. The influence of Parental Relationship on the Genetic Merit of Dairy Cows and Sires.

This research was undertaken to determine the relative merits of line-breeding, outcrossing and crossbreeding using progeny tested bulls of high merit as service sires. Mating plans were continued for the foundation cows and for first generation animals in each of the various mating systems. The foundation cows completed 104 lactations which averaged 15,939 pounds of milk, and 651 pounds of butterfat (2X, 305 days, M. E.).

Body measurements were taken on the females in each mating system at 6, 12, and 16 months of age and 90 days post partum. At 6 months of age 138 females were measured. Significant differences occurred between the group in depth and circumference of forechest and depth and circumference of paunch. The line-bred and Brown Swiss-Holstein (SXH) crosses were smaller than either the outcrosses or the Ayrshire-Holstein (A X H) crosses in these measurements. At 12 months of age 113 females were measured. Significant differences occurred among the groups in all measurements except depth and circumference of forechest. The S X H crosses were heavier and showed more length from withers to pins and withers to hips than the other groups. The A X H crosses were lighter and showed less height at the withers than the other groups. The line-breds were smaller than any of the groups in

circumference of the paunch. At 16 months of age 95 females were measured. Significant differences occurred among the groups in body weight, height at withers, length from withers to pins and depth of paunch. The S X H crosses were heavier than any of the other groups, followed by the outcrosses, line-breds, and the A X H crosses. The S X H were larger in all categories except depth of forechest and paunch and circumference of paunch. At 90 days post partum a total of 25 females were measured. There were significant differences among the groups in body weight, height at withers, length from withers to pins and length from withers to hips. It would appear from these results that as age advances the S X H crosses are heavier, taller, and longer than the other breed groups. The A X H crosses are not as heavy as the line-bred at 12 and 16 months of age, but are considerably larger in circumference of paunch. However, at 90 days post partum the A X H crosses are heavier than the line-breds.

Heifers from each mating system were placed on a standardized ration of free-choice alfalfa hay and 3 pounds of grain per day from 12 to 16 months of age. Feed efficiency rate of gain, total gain and hay consumption studies were made on 90 heifers. The only significant differences found between the mating system groups were in hay consumption. The outbred group exceeded all other groups. Significant differences occurred between sires within mating system group in rate of gain and total gain. Average daily rate of gain for the 90 heifers was 1.69 pounds and they gained a total of 202 pounds during the 4-month period. These results indicate that the variation between sires is more important and larger than the variation between mating system groups. (AH g2-24)

5. The Use of Progeny Tested Sires and Sons of Progeny Tested Sires.

A study was made to estimate the effects of culling out daughters from cows of low production capacity. The data were analyzed to determine the results of discarding daughters of all cows that produced less than 425 pounds of butterfat. Culling all daughters of these cows and the consequent exclusion of their descendants removed from the analysis 176 cows that averaged 661 pounds of butterfat. The 215 cows that were not excluded because of culling averaged 651 pounds of butterfat. These results show the ineffectiveness of heifer selection based on the low level of the dams' production. Usually in two generations, when good production proven sires were used, the progeny of low producing cows were about equal in ability to those of the rest of the group.

A study was made to estimate the relationship between production of a cow in her first lactation and the length of time she stayed in the herd. Data were obtained from 79 herds that had used Beltsville bred bulls. Results of within sire regression studies for age at disposal

and milk and butterfat production during first lactation were .024 month and .071 month, respectively. These results indicate no conflict between early maturity (high production) and length of life. They also suggest some success in keeping the higher producing animals in the herd.

The herds within each group were divided into low, medium and high levels of milk production to determine whether the level of production in the herd had any influence on the rate of culling the 1st lactation animals. Regressions of age at disposal on milk production were computed for each level of production within each group. The only significant differences found between the regressions were in the State and county institution herds. The highest regression was in the lowest producing group (.031).

A study was made to determine the effectiveness of using the contemporary comparison as compared to the daughter-dam comparisons in sire evaluation. Ten sires with a total of 324 daughters in one herd were used for the study. Records were adjusted for maturity and also for year changes in environment by a maximum likelihood technique (M.L.). Correlations were computed between differences of daughter-dam and daughter-contemporary for both fat and milk using ME records. These correlations were 0.70 and 0.64, respectively. When M. L. records were used the correlation increased to 0.89 and 0.92, respectively. These results indicate that when yearly fluctuations are removed by statistical measures, the differences between daughters and dams rank sires much the same as the differences between daughters and contemporaries. If it can be assumed that the M.L. records are an accurate measure of a cow's producing ability under a given environment, then using the contemporary comparison rather than the daughter-dam comparison is the best way to evaluate bulls. Correlations between daughter-contemporary difference ME and daughter-contemporary difference ME-ML were 0.96 for fat and 0.97 for milk. These high relationships are expected because records are made during the same environmental period.

A study of "Nicking" was made in three cooperator herds that had previously used a series of Beltsville bred bulls. Daughters of each sire were subgrouped according to their maternal grandsire. The response by daughters of the same sire out of dams from different lines of breeding could be studied by analyzing the means of the grandsire classes. Differential response would be an indication of "Nicking" or specific combining ability. A total of 13 sires and 38 grandsire groups were studied. In one herd significant differences existed between grandsire groups. When these data were adjusted for the depressing effects of inbreeding and year changes, the differences between grandsire groups disappeared. The other two herds did not show any evidence of nicking. These results are not surprising in this type of analysis. Any response would have to be very marked to be detected.

A study was made to determine the effects of inbreeding in different lactations of the same cow. One hundred eleven cows, each having 4 or more lactations, were used. They were by six different sires. Intra sire regressions of pounds milk per 1% inbreeding of the cow were: -105, -42, -18, -26, and -48 for 1st, 2nd, 3rd, 4th and average records, respectively. Corresponding regressions of pounds fat were: -3.6, -1.1, -1.3, -0.9 and -1.7. The only significant reduction in production due to inbreeding occurred in the first lactation. The other regressions were not significant. The regression coefficients for the individual sires varied within lactations but the differences were not statistically significant. (AH g2-25)

6. Genetic Methods for Developing Adaptability.

These investigations are to evaluate the effectiveness of certain genetic methods for improving dairy cattle adaptability to hot conditions through: (a) introduction of adaptability characteristics; (b) selection within existing breeds for further adaptability; and (c) hybridization of existing breeds by continuous crossing or developing new strains from a crossbred foundation. This work is in cooperation with the Georgia, Louisiana and Texas Agricultural Experiment Stations. Most of the semen services are supplied through the cooperation of the National Association of Artificial Breeders. All of the studies are contributing projects to the Southern Regional Dairy Cattle Breeding Project, S-49. The PL-480 grant fund cooperative project in Colombia contributes to this work..

- (a) Introduction of adaptability by crossing European breeds with Red Sindhi and Brahma cattle.

Analysis of milk and fat production data from the experiments of crossing Red Sindhi with Jerseys and Holsteins have been completed and published. The first lactation average of the F₁ Red Sindhi-Brown Swiss crosses was 3,286 pounds of milk and 160 pounds of fat. This was 42% less milk and 30% less fat than their purebred Brown Swiss herdmates, and 49% less milk and 35% less fat than their purebred maternal half-sisters. The first lactation average of the 3/4 Brown Swiss crosses was 5,047 pounds of milk and 225 pounds of fat which was 10% less milk and 2% less fat than their purebred herdmates. The Brown Swiss crosses were like the other crosses in that production was highly variable, persistency poor and many were highly temperamental. As with the Red Sindhi-Jersey and Red Sindhi-Holstein crossing, the Brown Swiss crossing has been discontinued.

At Texas A & M, all the 3/4 Jersey-1/4 Brahma crosses have calved one or more times. Although the average first lactation production of this group was 37% higher than for the F₁ crosses, the proportion that could not be milked and the variability in production was similar

to that for the F_1 crosses. This same pattern is appearing in the 7/8 Jersey crosses. This project has now shifted to inter se mating of crossbreds. Although too few in number to warrant conclusions, the level of production and docility appear better than in the fractional crosses.

(b) Selection within the existing breeds.

Genetic and environmental aspects of milk and fat production in the Louisiana State University Holstein herd have been studied. Heritability estimates for milk and fat yield were derived from the first lactation records of 222 daughter-dam pairs representing 21 sires. The heritability for both milk and fat was 0.24 and the genetic correlation between milk and fat yields was .882. These estimates are in good agreement with those reported by other workers. Efficiency of feed utilization was calculated from 357 records of 151 daughters of 17 Holstein sires. The coefficient of efficiency of these sire groups ranged from 23.3 to 28.4%. The heritability and repeatability estimates obtained from the paternal half-sib correlation analysis were .366 and .516, respectively. Although the heritability for feed utilization contains a sizeable sampling error, it would appear that feed efficiency is as heritable as either milk or fat production. There were no significant season of calving differences for milk, fat or feed efficiency. The heritability estimates obtained will be used in computing the selection indices for the cows in the breeding project.

The planned base population of 80 Jersey cows has been established in the Tifton, Georgia, herd. Twelve essentially unrelated Jersey sires have been used in establishing this base. The selection program aimed at improving volume and composition of milk has been initiated.

(c) Hybridization of existing breeds by continuous crossing or developing a new strain from a crossbred foundation.

In the crossbreeding study at Reidsville, Georgia, with Brown Swiss, Holsteins and Jerseys, the Holstein-Jersey crosses have produced above the "expected" (mean of the parents), whereas the Brown Swiss-Jersey crosses have been lower. The production of the Brown Swiss-Jersey crosses has been more variable than for the other crosses.

In a preliminary study of the performance of crossbreds versus purebred Holstein at Jeanerette, Louisiana, the average 305 day milk yield of the crosses was 650 pounds less than for the purebred Holsteins but the average butterfat content (3.48%) and solids-not-fat content (8.15%) of the Holsteins was less than desired by the local milk market. The breeding efficiency of the purebred Holsteins was also lower than for the crossbreds. During the past year the herd has been changed over to essentially a dry lot feeding program and it appears that the level

of production as well as milk composition of the purebred Holsteins is more responsive to this change than the crossbreds. Thus far the crossbreds in this herd by Holstein sires have produced better than the crosses by Brown Swiss sires. (AH g4-2, S5 AH-1)

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DAIRY CATTLE - PHYSIOLOGY
Animal Husbandry Division, ARS

Problem. Fundamental physiological research is required as a basis for improving lactational and reproductive performance of dairy cattle. Breeding failure is a major reason for the disposal of cattle from our dairy herds. There is a lack of basic information on the physiological action of hormones in controlling reproductive activity, correcting reproductive abnormalities and stimulating lactation. Research on physiological processes related to growth and development, nutritional requirements and to heat tolerance of dairy cattle is required.

USDA PROGRAM

This is a continuing program, almost entirely on basic research, conducted by physiologists and biochemists. The program is designed to elucidate the reproductive and lactational physiology of cattle utilizing physiological and biochemical techniques and to determine physiological mechanisms related to heat tolerance. The work is in progress at Beltsville, Maryland, and cooperatively at the Wisconsin, New York, Massachusetts, Texas, Louisiana, and Georgia Agricultural Experiment Stations. It is coordinated with the NE-41, W-49, and S-49 regional projects.

The Federal scientific effort devoted to the research in this area totals 8.6 professional man-years. Of this number, 2.7 are devoted to the physiology of reproduction, 4.0 to the physiology of milk secretion, 1.0 to the physiology of growth and development, 0.6 to environmental physiology, and 0.3 to program leadership.

A grant with the Veterinary School of the University of Sao Paulo, Brazil, provides for research on the anatomical and physiological characteristics affecting heat production and heat loss of Zebu, European and Zebu-European crossbred cattle and the nature and method of controlling the inheritance. Its duration is for five years, 1961-1966, and involves PL-480 funds with a \$63,293 equivalent in Brazilian Cruzeiros. (Pertains to Area 5 also)

Another grant with the Indian Veterinary Research Institute, Izatnagar, UP, India, supports studies on the physiology and genetics of characteristics influencing the adaptability of cattle and buffalo for dairy production. The duration of this work is five years, 1961-1965; it involves PL-480 funds with a \$195,624 equivalent in Indian rupees. (Pertains to Area 5 also)

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

The State experiment station scientific effort in this area totals 45.1 professional man-years divided among subheadings as follows: physiology of reproduction 26.6, physiology of milk secretion 10.0, environmental physiology 3.1, other physiology 5.4. A regional project on diseases affecting reproduction, NE-40, Pathology of Breeding Failures, is reported in Unit 2, Animal Disease and Parasite Research. Research on physiological aspects of infertility in cattle is coordinated through regional projects NE-41, Endocrine Factors Affecting Reproduction involving 9 States, and W-49, Physiological Mechanisms Affecting Fertility, involving 10 Western States.

Industrial research amounting to approximately 25 professional man-years is conducted primarily by the pharmaceutical companies and to some extent by feed manufacturers. Most of the work is in the field on the response of dairy cattle to hormones and antibiotics.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

A portion of this work is reported in Area 1, Animal Biology, because it has application to classes of livestock other than dairy.

1. The Corpus Luteum.a. The Corpus Luteum of the Estrual Cycle.

The mechanism responsible for the maintenance of pregnancy involves the maintenance of the corpus luteum which normally develops during each estrous cycle. Determinations of progesterone, cholesterol, DNA, RNA and percent functional luteal cells were made at 2-day intervals throughout the estrous cycle in order to obtain an estimate of the physiological activity of this CL. CL weights were similar in the 7-17-day period and were higher than the 3-5-day period, indicating that the major increase in weight had occurred by day 17. A decrease in CL weight occurred from the 7-17-day period to day 19. Percent dry weight increased from 17.8% at day 7 to 21.2% at day 17 and was 22.5% at day 19. Total progestogen (Progesterone + 4-pregnene-20 β -ol-3-one) per gram of fresh luteal tissue increased from 26.9 ug at day 7 to 50.7 at day 15 and then dropped to 9.1 at day 17. An apparent increase to 19.1 at day 19 was noted but this value (6 CL range 4-39 μ g/g) was much more variable. This decrease in CL progesterone in the 15-17-day period might indicate that this is the stage when the mechanism responsible for maintenance of CL during pregnancy becomes necessary. Total free cholesterol content (precursor for progesterone synthesis) increased to day 15 and then decreased with CL regression. If free cholesterol is expressed as a ratio of free cholesterol/DNA the differences are

not significant indicating that free cholesterol may be primarily a function of cell numbers. The RNA/DNA ratio, a measure of functional activity per cell, decreased from day 7 to day 17 with a significant drop occurring after day 13. This agreed well with changes in percent functional luteal cells as estimated by the Foley-Greenstein classification. (AH h5-6, cooperative with the University of Wisconsin)

b. Variations in Some Biochemical and Histological Characteristics of Bovine Corpora Lutea During Early Pregnancy.

Two experiments involving 40 heifers were used to study the level of function of the corpus luteum during early pregnancy. Experiment 1 was a comparison of day 14 of the estrual cycle and day 14, 28, and 42 of pregnancy. Experiment 2 compared day 18, 23, and 28 of pregnancy. Progesterone and total progestogen were lower, $P < 0.01$, on day 28 and day 42 of pregnancy than on day 14. A significant, $P < 0.01$, negative regression of progesterone and total progestogen content on day of pregnancy up to day 28 was found, -6.07 and -6.32 micrograms, respectively. These regressions appeared to be linear. The level of 4-pregnene-20B-ol-one did not appear to vary with stage of pregnancy. Free cholesterol concentration increased significantly between day 14 and 28 but tended to return toward the day 14 level by day 42. The regression of free cholesterol between day 14 and 28 of pregnancy was 35.6 micrograms per gram per day, $P < 0.01$, and appeared to be linear. Mean concentrations of DNA were not different but RNA decreased with increasing length of gestation. A decreased percentage of functional cells was apparent histologically at day 23 of pregnancy and at later stages as compared to day 14 or 18 of pregnancy. The latter named stages in turn had fewer functional cells than the unbred heifers of day 14 of the estrual cycle. (AH h5-6, cooperative with the University of Wisconsin)

c. Progesterone Content of Corpora Lutea and Reproductive Organ Weights in Normal and Pregnant Cattle.

Statistical study of organ weights in more than 80 head of pregnant cattle has shown, as expected, that ovarian weight increases appreciably with age of animal. A similar, but far less pronounced change occurs in corpus luteum size.

A similar study of corpus luteum weight (uncorrected for animal size or weight) in 40 normal cattle at five stages of the estrous cycle showed the expected increase in size to mid-cycle (mean 5.3 gm. at day 12) followed by a decrease to a mean of 318 gm. at 18-19 days.

Date on the progestin content (progesterone and 20b-hydroxyprogesterone of the corpus luteum from a sample of six normal cattle each at 6, 12,

and 18 days of the estrous cycle showed, for the two components, respectively, 80 and 2.6, 126 and 51, and 75 and 23 micrograms. Corresponding concentrations in micrograms per gram of tissue were 22.6 and 0.7, and 23.4 and 9.0, and 16.7 and 5.3. To the extent that content reflects secretion rate, progesterone production rises and falls with corpus luteum growth and regression. The hydroxyprogesterone component, however, is virtually absent in early growth stages (3% of total progestins) but becomes a major fraction of the total at later stages (28 and 24%). In a sample of corpora from pregnant cattle, progesterone and 20 β -hydroxyprogesterone averaged 21.5 and 16.0 micrograms per gram, the latter component now amounting to 43% of total progestins. The biological potency of hydroxyprogesterone in the cow is being assayed through its comparative effectiveness in blocking heat and ovulation. (AH h5-4, cooperative with the University of Massachusetts)

d. Effects of Experimental Endocrine Treatment of Animals on the Activity of Their Corpora Lutea.

Attempts have been made to modify CL activity of the cow using several substances which may be involved in the function and maintenance of this gland. The progestogen content (progesterone and 4-pregnene-20 β -ol-3-one) of the corpus luteum was used as the measure of luteal activity.

Oxytocin. Control CL were removed from 10 heifers and after a recovery cycle, they were injected on days 12 and 13 with oxytocin. The CL removed 24 hours after the last injection showed a significant increase in progestogen (271 μ g (control) vs 421 μ g (oxytocin treated) $P < 0.01$).

Unfractionated pituitary extract. Control CL were removed from 8 heifers on day 14 and after a recovery cycle, they were injected on day 12 or 14 with an unfractionated pituitary extract. CL were removed 48 hours or 6 hours later and showed an increase in progestogen content (314 μ g) when compared to control CL (246 μ g).

Luteinizing hormone (LH). Control CL were removed from 5 heifers on day 14 of the estrous cycle and following a recovery cycle, they were treated with LH on day 11, 12, or 13. CL were removed on day 14 and showed a decrease in progestogen content from 268 μ g to 185 μ g. Three 8-month-pregnant animals showed no change in progestogen content of their CL following treatment. Lactogenic Hormone (ovine) and Human Chorionic Gonadotrophin (HCG) were also administered in a similar fashion to cycling heifers and showed no effects upon the amounts of luteal progestogen. (AH h5-6, cooperative with the University of Wisconsin)

2. Embryo Survival in Dairy Cattle.

Death of embryos during early stages of development is recognized as the most frequent cause of repeat services to dairy cattle. It had not been determined previously whether pregnancies could be maintained in ovariectomized cattle during the first few weeks of embryonic growth. Pregnancies were maintained by injection of exogenous hormones in 13 of 14 cattle ovariectomized 5 to 7 days postbreeding. Two of the embryos died at approximately 50 days postbreeding; 11 others were normal when the cows were killed 35 to 60 days postbreeding. The pregnancies were maintained with progesterone and estrone or with progesterone alone. Embryo survival was compared in intact and ovariectomized cows of low fertility (repeat-breeders). Embryos survived in 3 of 19 intact controls (15%) and in 3 of 14 cows ovariectomized 5-7 days postbreeding (21%). Uteri of 4 ovariectomized cows contained degenerate embryos 35 days postbreeding. It appears that in ovariectomized repeat-breeder cows the majority of embryos cannot survive past a certain age (approximately 18-20 days) even though hormone administration is sufficient to maintain pregnancies in a high percentage of first-service animals. The results to date fail to suggest that aberrant ovarian hormone secretion causes embryonic death in repeat-breeder cattle. Results support the hypothesis that embryonic death occurs in cattle before the corpus luteum begins to regress; the reverse possibility is thus not supported. (AH h5-3)

3. Repeat Breeders.

To explore causes of repeat breedings in the Louisiana State University herd, a study was made to characterize the biochemical and physiological properties of cervical uterine fluids in both normal and repeat breeding cows and heifers. There was considerable variation in the pH, Na, K, Ca, Mg, inorganic phosphate, reducing sugars and protein content of the fluids of cows, irrespective of their reproductive background. However, the fluids from the repeat breeders tended to have a higher concentration of electrolytes. Chromatographic studies indicated the presence of complex polysaccharides in both cervical and luminal fluids. There was no evidence of simple sugar such as glucose and fructose in these fluids. (AH g4-1)

4. Experimental Alteration of the Estrous Cycle in Cattle.

This work is part of a study to determine the factors which control ovulation and regulate the estrous cycle in cattle. Previous work had shown that injection of oxytocin following ovulation shortens the following estrous cycle length from the normal 22-day interval to approximately 8-10 days. The mechanism of action of this posterior pituitary principle is believed to be through regulation of the

activity of the anterior pituitary gland which produces the gonadotrophic hormones which in turn control reproductive function. In the present study oxytocin injection was used as an experimental tool to study the effect of luteal function on embryo development and survival. Seventy-nine oxytocin-treated and untreated control heifers were killed 15 days after insemination and their embryos, ovaries, reproductive tracts and endocrine glands studied. Seventy-four percent of the untreated inseminated heifers had normal embryos at 15 days and this recovery was significantly ($P < .01$) reduced to 42% in the oxytocin-treated heifers. Thirty-five percent of the oxytocin treated heifers returned to estrus before 15 days.

The progesterone content of the **corpora lutea** of the treated heifers that returned to estrus and had no embryos was lowest; those treated heifers that did not return to estrus but had no embryos had a slightly higher progesterone content in their corpora lutea, but the level was significantly below that of the untreated heifers. Oxytocin treated heifers with normal embryos had as much progesterone in their corpora lutea as the untreated control heifers. The data suggest that the response to oxytocin is an "all or none" phenomenon which once initiated, results in marked inhibition of luteal development and progesterone production and in embryonic death. If the response is not evoked, the corpus luteum develops normally, and produces a normal amount of progesterone. The data also suggest that in some cases a low level of progesterone production is capable of preventing a heifer from returning to estrus, but is not capable of maintaining a normal embryo.

Two new commercial progestational compounds, Provera and Enovid, were fed to cows to regulate the estrous cycle. Provera was fed to 32 beef cattle. Although the compound was effective in regulating the cycle lengths, the percentage conceiving after treatment was low, about 25%. Enovid was not effective in inhibiting estrus since 11 of 18 cows fed the compound came into estrus during the 20-day feeding period.

These studies have contributed to an understanding of the nature of the early embryo mortality problem in cattle. The data show that inhibition of luteal function, which can be caused by a variety of treatments, can cause embryo death prior to the 15th day after breeding, and that cows with normal embryos at this stage of pregnancy are likely to be producing normal amounts of progesterone. The data also suggest that factors which cause the development of cystic corpora lutea are also likely to cause embryo mortality. (AH h5-3, cooperative with the Cornell University)

Experiments were continued on the synchronization of estrus. Provera was found to be effective in inhibiting estrus and ovulation but

although the compound was effective in regulating cycle length, fertility was low. The percentage conceiving after this treatment was only 25% in trials on beef cattle. Trials conducted this year with dairy cattle (Holstein heifers) resulted in good synchronization and 56% of the heifers conceived when bred artificially at the synchronized estrus. An attempt was made to reduce the hormone feeding period (20 days) and good synchronization was obtained with a 15-day feeding period and 60% conception rate, again in Holstein heifers. Experiments involving Hereford heifers showed essentially similar results to those obtained previously, good synchronization but low fertility. (AH h5-3, cooperative with Cornell University)

5. Tubo-Uterine Junction Opening and Closing in Cattle.

An experiment is in progress to determine whether the tubo-uterine junction of the cow undergoes a cyclic opening and closing. The left oviduct of heifers was ligated at the ovarian end at about the time of ovulation. The animals were killed at various times after operation, a hemostat being placed just anterior to the junction prior to removal of the reproductive tract from the body. Presence or absence of gross distension of the ligated oviduct is taken as evidence of patency of the tubo-uterine junction. Six heifers showed distension, 2 slight distension and 3 no distension in the 3-4 day period following estrus. One animal at 6 days post estrus showed no distension. These data suggest a decreased resistance on the part of the tubo-uterine junction to flow of oviduct secretion about 72 hours after ovulation. This agrees well with the time when the ovum normally enters the uterus of the cow.

The influence of ovarian hormones on this phenomenon is also under study. Two heifers treated with 25 mg. estradiol-17 β daily for 5 days beginning at ovulation still had distended oviducts when killed 161 and 167 hours later. Further studies are planned in which progesterone as well as estrogen in more physiological doses will be utilized. Histological examination of the tubo-uterine junction is underway and wax-plate reconstructions are being made in an attempt to find a physiological or morphological change which can explain the results being obtained.

Previous studies indicated a decreased resistance on the part of the tubo-uterine junction to flow of oviduct secretions about 72 hours after ovulation. The apparent block prior to this time has been studied during this year utilizing in vitro insufflation to measure the pressure required to force air through the oviduct and into the uterus. Removal of the tubo-uterine junction itself produced no appreciable pressure drop. Progressive removal of sections of the isthmus permitted gas to be passed through the tube at greatly reduced pressures. Thus the blocking mechanism in the cow appears to reside

in the lower 4-5 CM of the isthmus, rather than the junction as in some other animals. Experiments are now being conducted in which both circular and longitudinal muscular activity are being recorded, as well as pressure required to force air through the oviduct. Pharmacological and hormonal agents will be tested in vivo and in vitro for their effect on the blocking mechanism. Sperm transport through the junction is also being studied. Dead spermatozoa from the bull, rabbit, rat and human can be transported through the tubo-uterine junction in the rat, with cells appearing in the oviduct within a few hours after uterine insemination. (AH h5-4, cooperative with the University of Massachusetts)

B. Physiology of Milk Secretion

The Relationship of Histamine to Antibodies in Cow's Milk.

Antibodies against antigens occur in milk when the antigens are injected by intramammary infusion, subcutaneously or intramuscularly. The antibody-containing milk has been proposed as having medical usefulness in conferring immunity upon humans or animals ingesting this milk and the milk has been termed "protective" milk. In order to confer immunity, absorption of ingested antibodies must take place through the digestive tract and the antibodies must then be transferred to the circulation. The ability of untreated calves and calves treated with Escherichia coli "protective" milk to survive E. coli injections was studied. Histamine is released in antigen-antibody reactions and was, therefore, followed routinely in blood samples during the production of the "protective" milk and during the survival tests for the protective ability of the E. coli milk. Blood histamine concentration was 0.15 µg histamine per ml whole blood in 8 cows after intramammary infusions of E. coli (75 samples, range 0.1 to 0.3). No definite trends in blood histamine concentrations were evident. Histamine concentration was found to increase in calf blood after birth, being 0.13 ug/ml on the day of birth and 0.21 one day later (9 calves). Calves exhibited a higher blood level than adult animals, histamine concentration being 0.18 µg per ml blood (13 calves, 72 samples). When challenged with sublethal intravenous doses of E. coli, control calves (not fed "protective" milk) exhibited a rise in blood histamine concentrations 1, 2, and 3 days after injection (3 trials). When given orally, there was little change in blood histamine content. In 7 paired experiments utilizing large lethal doses of E. coli, there was little change in blood histamine concentration during the survival period of several hours in either group (control or "protected"). (AH gl-7, h5-1)

C. Physiology of Growth and Development

1. Characterization of Vaginal Temperature Patterns in Cattle.

Previously reported work demonstrated that body temperature changes are indicators of the functional status of the corpus luteum. The effect of progesterone on body temperature had been demonstrated in normally cycling, ovariectomized and pregnant cows. During these studies continuous recordings of vaginal temperatures were employed and a diurnal pattern of temperature rhythmicity had been noted. This rhythm has been characterized during the past year in (1) normally cycling cows, (2) ovariectomized cows, (3) pregnant cows and (4) young heifer calves. Sixty-seven percent of the diurnal temperature rhythms describes a diphasic pattern whereas 23% were found to be monophasic and 7% polyphasic. Horizontal linear patterns, i.e., aphasic, were observed in 3% of the curves obtained. In general, temperatures were elevated in the mid-morning and afternoon and were low during the evening and early morning hours. Calves showed the highest mean temperatures (101.6° F.), while the ovariectomized group showed the lowest mean temperatures (100.6° F.) of the animals studied. These studies represent the first complete characterization of diurnal temperature patterns in cattle. The utility of using single daily temperature measurements, rather than continuous recordings, as an indicator of reproductive function appears rather limited for practical field use. (AH h5-3)

2. Body Composition During Growth.

Chemical and physiological measurements of body constituents during growth is a prerequisite for an evaluation of the efficiency of the conversion of the energy value of feeds into muscle tissue. Characterization of tissue and body composition would make it possible to accurately determine whether a body weight gain is in fat, muscle or water and the relative proportion of each. This study was initiated during the past year to determine changes in body composition, more particularly, the extracellular water compartment, by means of distribution of an exogenous material during growth in male and female dairy cattle. Estimates of the size of the extracellular body water compartment of growing calves were determined by observing the distribution of sodium thiocyanate. One-hundred and forty-six estimates of thiocyanate space were made using 76 calves. Data were collected on heifer and bull calves up to 800 lbs. of body weight. The results show that extracellular water, as estimated by thiocyanate space, decreased rapidly in growing calves from about 48% of body weight at birth to about 30% at 1 year. This decrease occurred earlier in heifers than in bulls--during the first 4 months in heifers and in the 5- to 7-month period in bulls. The thiocyanate space of young bulls tended to be higher than in heifers of the same weight. In bulls the pronounced

decline in thiocyanate space coincided with the probable time of onset of sexual maturation. (AH h5-3)

3. Influence of Vitamin A Deficiency on Cerebrospinal Fluid.

Work was begun in 1960 to study the mechanism whereby the cerebrospinal fluid (CSF) pressure is increased in vitamin A deficiency in calves. This research has involved three distinct phases (1) the influx of thiocyanate (SCN) ion from the blood to the CSF in normal and vitamin A deficient calves, (2) the efflux or rate of disappearance of SCN from the CSF, and (3) direct measurements of the rate of replacement and absorption of CSF. The results of the first phase of the work reported in 1960 indicated that SCN moves from the bloodstream to the CSF at rates quantitatively similar in normal and deficient calves. The rate of disappearance of SCN from the CSF (phase 2) was found to be slower in the deficient calves, thereby indicating a slower rate of absorption. When the rate of replacement of CSF was studied directly by removing the fluid and measuring the time necessary for replacement (phase 3), it was found that vitamin A deficient calves replaced the fluid 2 - 2.5 times more rapidly than normal animals. Estimates of absorption capacity, however, indicated even larger differences, suggesting that differences in absorption represent a larger factor than formation of fluid. These results of phase 3 thus show a considerable degree of agreement with the slower rate of disappearance of SCN observed in vitamin A deficient calves. Underabsorption, therefore, appears to be a greater factor than overproduction in the etiology of the CSF pressure increase in vitamin A deficiency.
(This work is supplementary to work under AH h1-3).

D. Environmental Physiology

These studies deal with the determination of the anatomical and physiological characteristics affecting heat production and heat loss of dairy cattle under hot conditions and the nature of the inheritance of these characteristics.

1. Effect of High Environmental Temperatures on Reproductive Performance of Heifers.

At Beltsville, in cooperation with the Beef Cattle Research Branch, a series of studies have been conducted to determine the effect of prolonged heat stress on reproductive performance and certain physiological responses of two-year-old, virgin, Angus, Shorthorn, and Hereford heifers. The initial study was made with six pairs of Shorthorn heifers. One of each pair was kept in a psychrometric chamber commencing in December of 1959 for a period of 29 weeks at 90° F. and 60% relative humidity. Five of the animals, under heat stress, ceased to cycle after five weeks while the control group continued normal cycling. In the noncycling heifers follicle formation

continued without maturation and ovulation. By the 21st week, the heat group reestablished normal estrous cycles and were bred. Pregnancy was maintained in this group for 66 days under experimental conditions.

In the second study six heifers were kept in the psychrometric chamber for 14 weeks at 90° F. beginning in September 1960 and two other groups were kept in barns under near ambient temperature conditions, one group under artificial light and the other with natural. Although the rectal temperatures of the chamber group rose higher than the similarly treated animals in the previous winter study, only one animal ceased to cycle during the period. In this case, temperament was probably more responsible than the high temperature. During the test, the average cycle length was 20.3, 20.8, and 21.3 days for the control, heat and light groups, respectively. This was no change from the intervals recorded for the three months prior to the experiment.

To further test the hypothesis that cessation of the estrous cycle is associated with the degree of stress, six of the heifers from the second study were held over and allowed to become conditioned to summer conditions in 1961. These animals were placed in the chamber in mid-July for 8 weeks at 100° F. Body temperatures rose to high levels (average 105.4° F.) in the first week and this time the estrous cycle was disrupted indicating a relationship to level of stress. The fourth study was made at 90° F. in late 1961 with Hereford heifers. The results were similar to that for the Angus heifers in the previous year. The findings thus far indicate that the stage of adaptation, that is whether the animals are acclimated to winter or summer conditions, is quite important in their response to heat stress and the resulting effect on the estrous cycle. Under field conditions, this means a sudden onset of hot weather in the spring is more likely to effect reproductive performance than similar temperature conditions later in the summer. (AH g4-1) (Also reported in Area 3)

2. Effect of High Temperatures on the Hair Coat of Cattle.

To determine the influence of environmental temperature on hair coat of cattle, studies were made under both ambient conditions in various seasons of the year and constant 90° F. temperature for periods of 12-30 weeks. The photoperiod in the chamber corresponded to that normal for the season and a combination of fluorescent and incandescent lights were used to provide the foot candles of light corresponding to the 9:00 a.m.-3:00 p.m. average in an open barn. Milking Shorthorn heifers subjected to the 90° F. temperature in December shed most of their winter coat by the fifth week while the coat of the controls continued to grow. The heat group shed a second time at about 15 weeks. The initial shedding reduced the coat to that normally expected in summer for Shorthorns (average depth .55 inches). After the second shedding, coat depth was reduced to .20 inches. Since

the artificial lighting may have been a factor in the results, a third group was added in the second trial, that of ambient conditions with artificial light corresponding to that of the chamber. The second study was for 14 weeks from September-December. The hair coat of the artificial light-ambient temperature group grew slightly slower than the ambient controls, but by the 11th week the means for the ambient groups were nearly the same. The hair coat of the heat group continued to grow for the first four weeks, but remained very stable thereafter. There was evidence of thinning of the hair coat in the heat group as the test progressed, but not a complete shedding as occurred in the previous winter group. At the close of the 14-week test period, the control group was subjected to the 90° F. temperature. After three weeks, all animals had shed 50% or more of their winter hair coat. Present results indicate high body and/or ambient temperatures play an important role in the type of hair coat that cattle have at a given time and depth of hair coat and rate of shedding are important in the animal's ability to adjust to high ambient temperatures. (AH g4-1)

3. Blood Constituents Related to Environmental Changes.

This work is part of a study concerning the relationships between blood levels of ketones and short-chain fatty acids on milk fat production. Total blood ketone bodies in six cows were determined at 10-day intervals over a period of 18 months. There was considerable rise in ketone bodies during fall and early winter and several smaller peaks occurred in spring and summer. These blood ketone changes were correlated with the air temperature for fall and winter seasons and with maximum water temperature for the spring and summer, providing circumstantial evidence for an influence of cold and heat stress on levels of blood ketone bodies. In late winter and late summer the effects of cold and heat, respectively, were minimal. Analysis of variance indicated that the largest factor was environmental. However, only 30% of the variation that could be attributed to environment was accounted for by temperature. There was a tendency for cows to be higher in ketone body concentration during the first 60 days of lactation, but this tendency was not consistent. The effect of both cold and heat stress was to increase blood ketone bodies. Correlations with minimum winter air temperatures on days previous to the taking of blood samples show that there is a lag of 2-3 days between temperature and level of ketone bodies. For warm weather periods, maximum water temperature taken in an open tank seemed to give better relationships with ketone body level than air temperature. A similar lag of 2-4 days exists between both temperature and response in level of ketone bodies. It would appear that the effect of cold on ketone body level begins when the air temperature drops below 35° F. The effects of heat are consistent with the view that air temperatures above 85° F. place stress on cows and this may be accentuated by high humidities. The lack of response in late winter and summer suggests that adaptation to extreme temperatures occurs. (AH h5-1)

To determine the relation of blood ketones, blood glucose and blood cell volume to changes in rectal temperature under heat stress, 12 mature, nonlactating Holstein cows were paired by weight and placed on experiment in October 1961. The cows were fed at 115% of maintenance and actual feed consumption recorded to investigate the effect of feed intake on the various physiological measurements. One animal of each pair was kept in a psychrometric chamber for alternating two-week periods at 90 and 70° F. with 60% relative humidity, while pairmates were kept under prevailing ambient temperatures (40-78° F.).

Blood cell volume was significantly lower in the chamber group and there was a significant difference between days within groups. The cell volume of the chamber group declined during the first week of each of the 90° F. periods then rose slightly the second week, while in the control group there was little similarity of patterns in the three test periods. Indications are that under constant environmental conditions, repeatability of response is high while under natural conditions, the interaction of environmental factors is such that responses are not predictable. Significant differences between cows indicate that each cow has her own particular range of blood cell volume.

Significant differences in blood ketone levels were found between periods within both groups and between days within the control group. Blood glucose levels were highly variable but only periods within groups were significantly different. It appeared under these experimental conditions, that heat stress had little effect on either blood ketone or blood glucose levels. However, it should be pointed out that the association between ketones and heat stress may be seasonal with little relationship being shown during the fall season.

There were significant negative correlations between rectal temperature and blood cell volume (-.24) and rectal temperature and blood ketone levels (-.28) in the chamber group. Data from four Angus heifers subjected to 100° F. and 60% relative humidity showed highly significant declines in blood cell volume (40.5 to 28.8%) and blood ketone (1.32 to 0.84 mg %) over a seven week trial, with correlations of (-.70) and (-.64), respectively, with rectal temperature. Rectal temperature and respiration rate was significantly correlated in both the chamber group (.68) and the control group (.37). Dry matter intake (24 hours prior to sampling for day 15) showed positive correlations with blood ketone levels, however, the relationship was significant only in the Holstein control group (.82). The correlation of dry matter intake and blood glucose levels was positive but significant only in the chamber group (.77). A possible explanation is that in the control group where there were no feed refusals, blood ketone levels were affected mainly by feed intake, while in the chamber group some animals

refused a large portion of their feed and fasting may have caused a rise in blood ketone levels. Blood glucose, like dry matter intake, was quite stable in the control group, while in the chamber group blood glucose decreased as dry matter intake declined. Correlations between dry matter intake and rectal temperature were not significant. Respiration rate and dry matter intake in the chamber group showed a significant negative correlation (-.72). From these studies it is evident that: (1) heat stress is associated with a decline in blood cell volume and under higher levels of stress this response is greater and there is less chance for recovery, (2) feed intake is associated with changes in blood ketones and glucose levels, while the relationship of heat stress on blood ketones independent of feed intake is not clear, and (3) high respiration rates may prevent normal feed consumption, due to the greater concern of the cow to breathe than eat. (AH g4-1)

4. Effect of Hot Conditions on the Physiological Responses of Dairy Heifers.

At Louisiana State University, 9 yearling heifers of Jersey, Holstein and Red Sindhi-Holstein (F_1) breeding were kept in a climatic control chamber under cool conditions for a 78-day period and then exposed to 90° F. daytime and 75° F. night temperatures for a 40-day period. Weight gains were reduced markedly during the first 20 days but gains returned to normal levels in the third and fourth 10-day periods. Reduction in rate of gain was associated with an increase in water consumption and decline in forage dry matter intake, but after adjustment to the heat, forage dry matter intake returned to nearly normal levels. Blood volumes were studied at the end of the cool and hot periods. There was no significant change in plasma volume, but there was a marked reduction in the red cell volume following exposure to the hot conditions. This change was associated with changes in respiratory activity. Rate of thyroxine utilization declined upon exposure to hot conditions, but plasma protein bound iodine increased. Therefore, no significant change in daily thyroxine utilization was evident. Oxygen consumption per $W \cdot 7$ and digestibility of dry matter were higher at the end of exposure to hot conditions than at the end of the exposure to lower temperatures. None of the responses studied showed sufficient correlation with rate of gain to be considered as a satisfactory index of heat tolerance.

An additional study of thyroid and metabolic activity with yearling Holstein heifers was made for a 69-day period under cool and hot conditions. The mean plasma level of 17 hydroxycorticosterone increased from 1.7 micrograms % under cool conditions to 4.5 during heat exposure. A temporary eosinophilia occurred immediately upon exposing the animals to heat which was indicative of adrenal-cortical insufficiency. The eosinophilic condition rapidly disappeared and was

never followed by eosinopenia. Serum PBI and thyroxine utilization secretion rates were significantly lower under hot conditions. Weight gains were markedly reduced under the second 12 days of heat exposure. Rate of gain and dry matter intake were highly correlated. Respiration rate and body temperature showed significant adverse effects from heat exposure but were not highly correlated with rate of gain. Estimated heat production (kilocalories cwt .72/hr) was highly correlated with serum PBI and thyroxine secretion rates (mg/cwt/day). Measures of adrenocortical response were not significantly associated with any measure of thyroid activity. (AH g4-1)

5. Influence of Heat Stress on Rumen Volatile Fatty Acid Levels.

Two experiments have been conducted at Beltsville to study the effect of 90° F. temperature on rumen VFA levels; one with 12 mature, nonlactating Holstein, six of which were kept in a psychrometric chamber for 12 weeks of alternating 2-week periods of constant 70 and 90° F. temperatures with 60% relative humidity while pairmates were housed under prevailing ambient conditions (40-78° F.). In the second trial five Hereford heifers were kept at 90° F. for 12 weeks while the pairmates were housed under ambient conditions (36-56° F.). All animals were fed at 115% of maintenance requirements. Rumen samples were taken approximately five hours after morning feeding by stomach tube. VFA content was determined by column chromatography. The total fatty acid levels were only slightly lower in the chamber groups (Holstein 90.3 meq/lit and Hereford 100.6 meq/lit) than the control groups (93.7 and 106.6 meq/lit), but acetic acid portions were significantly lower in the chamber groups (Holsteins 59.8 and 62.8 and Herefords 52.9 and 61.2). Rectal temperature was correlated with total VFA levels in the Holstein (-.78) and Hereford (-.49) chamber groups. In the Hereford chamber group, total VFA levels were correlated with feed intake (.49) and water intake (.37). From present data, it is conceivable that heat stress, as measured by increased rectal temperature, respiration rate, water intake and decreased feed intake, lowers the level of rumen VFA content. Present evidence also indicates a good relation between the ability to re-adjust to VFA levels under hot conditions and general tolerance. (AH g4-1)

6. Evaporative Losses of Holstein Cows at 70 and 90° F.

Six mature, nonlactating Holstein cows were kept in a psychrometric chamber for 12 weeks of alternate 2-week periods of 70 and 90° F. At weekly intervals the total evaporative loss was determined from the difference between the weight of the animal at 0800 and 1100 hours, less the weight of urine, saliva and feces collected during the three hours. Respiratory evaporative loss was estimated from the

volume and moisture content of the expired air. The difference between total and respiratory losses was used as an estimate of surface evaporation. Body surface area was determined with a surface integrator. The average total evaporation increased from 118.2 gm/m²/hr at 70° F. to 221.0 after one week at 90° F. and 243.2 gm/m²/hr after two weeks at 90°F. Respiratory evaporation accounted for 49.3, 65.7, and 69.5 gm/m²/hr during the same intervals. Surface evaporation increased from 69.0 gm/m²/hr at 70° F. to 155.2 and 173.8 gm/m²/hr after one and two weeks at 90° F. Both surface and respiratory evaporation increased at 90° F., but surface evaporation did so to a much greater extent. Surface evaporation accounted for 58.3% of the estimated total evaporative losses at 70° F. and 70.3% and 71.4% after one and two weeks at 90° F. From this study it is evident that Holstein cows can effectively use surface and respiratory cooling under hot conditions (20.0 therms of energy per day). The present study also lends support to mounting evidence that between cow variation in the ability to utilize surface evaporation is large in the Holstein breed. (AH g4-1)

7. Heat Tolerance Studies in Brazil.

Studies on European breeds (Brown Swiss, Holstein, Jersey); Zebu breeds (Nellore and Kankrej) and crosses of European and Zebu in a psychrometric chamber at the Instituto de Zootecnia, Brazil, under 105° F. temperature showed that cholinesterase activity of the blood declines quite rapidly upon exposure to heat stress. The decline is most marked in pure European breeds and the recovery period is also longer in the pure European breeds. The change of cholinesterase in the Zebu-European crosses seems to be more like that of the Zebu than the European breeds. (S3-AH-7)

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DAIRY CATTLE - NUTRITION AND MANAGEMENT
Animal Husbandry Division, ARS

Problem. Information on the nutritional processes and requirements of dairy cattle are needed to obtain a more precise evaluation of feeds and rations as a basis for improving feeding practices on farms. Shifts in sources of nutrients fed to dairy cattle require studies on the optimum combination and specific supplements needed in order to provide for the most profitable production. Also, dairymen need to reduce costs including man-hours of labor and develop better management in the use of improved types of dairy equipment and feeding, bedding, and milk handling systems.

USDA PROGRAM

The current program is conducted by biochemists, nutritionists, and dairy husbandmen. At Beltsville, studies are in progress on the factors which contribute to the heat production and maintenance requirements of grazing animals; the relationship between net energy, metabolizable energy, and total digestible nutrient values in dry roughages, silages, green roughages and concentrates; and the relationship between digestibility and the chemical composition and solubility of various feed constituents. Calorimetric techniques are being applied to studies on the effects of dietary and physiological factors on energy metabolism and requirements of cattle. A cooperative project at Tifton, Georgia, has been recently initiated on the residues in milk resulting from the ingestion of pesticides and herbicides associated with the treatment of animals and crops. At Cornell University a Nutritionist is being trained in radioisotope methodology and technical problems associated with exposure to Strontium 90 and similar radiation products.

At Beltsville, Maryland, research is being conducted on the effects of crop maturity, moisture content, preservatives, including methods of handling and conditions of storage, on the chemical quality, palatability and feeding value of silages. In conjunction with this effort, biochemical studies are being made to determine the effect of the composition of forage at the time of ensiling and of varying imposed conditions on the composition of the resulting silage. Microbiological studies are being carried out to obtain information on the micro-organisms responsible for the fermentation process of ensiled forages and on the relationships of these processes to the biochemical and nutritive changes that occur in ensiled forage. Related to the Beltsville studies is cooperative work at Lewisburg, Tennessee; Willard, North Carolina; and Puyallup, Washington. The objective of the work at the former station is to determine the effectiveness of various practical ensiling procedures by varying such factors as moisture, preservatives, type of silo, etc. At North Carolina, comparisons are

being made of upright and bunker type silos. At Washington, the scientists are studying comparisons of bunker and tower silos. Pasture studies at Beltsville, Maryland, involve the effect of varying stocking rates on nutrient yields per acre and on production per animal. In cooperation with the Washington State Experiment Station at Puyallup, Washington, work is being carried out to determine dry matter consumption and digestibility of nutrients from pasture species.

A cooperative project at Logan, Utah, has been undertaken to measure the variations in efficiency of forage utilization by dairy heifers and to determine the factors which account for these variations.

At Beltsville, Maryland, a continuing study is underway to obtain information on the extent of the variation in amount of dry matter and total digestible nutrients the dry, nonpregnant, mature cow requires to maintain body weight under practical conditions and to study and evaluate various factors that may influence the maintenance requirements.

The work at Beltsville, Maryland, also consists of studies on wilted silage as a forage for growing dairy heifers, the vitamin and mineral requirements of calves and deficiency symptoms using a synthetic type of diet with particular emphasis on vitamin A and magnesium deficiency. At Willard, North Carolina, the research involves pasture utilization by young, growing cattle.

Scientists at Beltsville are engaged in studies on the environmental conditions and the mechanisms of infection involved in bovine mastitis. They are also making a comparison of hand vs. machine milking of dairy cattle. In cooperation with Agricultural Engineering, Entomology, and Eastern Utilization, research is in progress on electrically-controlled and operated equipment for reduction of labor in dairy cattle management; on the evaluation and development of physical methods for control of flies and other dairy cattle pests; and on the relationship between management practices and milk quality including flavors.

Cooperative work with Agricultural Engineering and with the Georgia Coastal Plain Experiment Station is being conducted on the influence of management practices and other environmental factors on the adaptability of cattle to the Southeastern United States.

The Federal scientific effort devoted to research in this area totals 26.4 professional man-years. Of these 6.0 are in digestion and metabolism, 11.1 in forages, 2.6 in nutritional requirements, 3.1 in calf feeding, 2.7 in management practices, and 0.9 in program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations reported a total of 87.6 professional man-years of which 22.0 are on digestion and metabolism, 7.5 on concentrates; 30.0, forages; 7.9, nutrients; 8.7, calf feeding; and 11.5, management practices, equipment, and facilities.

Research in digestion and metabolism seeks to develop basic information about the role and action of rumen microorganisms in the nutrition of the dairy cow, characterization of the most desirable types of organisms and determinations of the ideal media and conditions for maximum rumen fermentation. Other studies are concerned with the development of rapid chemical and/or bacteriological tests for predicting digestibility and the reasons for differences in net energy values between roughages and concentrates. Ketosis and milk fever is under investigation to learn why some cows are affected and some are not. Intermediary metabolism, the process of converting the products of digestion into milk and butterfat, is another basic problem under intensive study.

Current problems under investigation on concentrates include the evaluation of innumerable nonprotein nitrogenous products, the pelleting of the ration including grain, and the effects of feeding on udder edema. Other studies seek to determine the effects of heating on the availability of certain nutrients in the ration, the value and use of sorghum grains, and the losses incurred through fermentation of grain in silage.

Research on forages deals with the losses incurred in the digestion of forages, especially rumen fermentation; ways in which high quality (principally low fiber, high protein content) can be maintained or improved, and palatability and its effect on consumption. Several stations are evaluating different methods of feeding forage, i.e., grazing, as a soiling crop, and rotation vs. strip grazing. Other stations are studying forage preservation, comparing the feeding value of field cured forage vs. artificial drying, vs. silage. Still other stations are investigating the effect of the physical character of the forages when fed, such as long hay, chopped, ground, pelleted, or cubed. Virtually every State is involved in one or more phases of forage research, including the value of locally adapted crops and the investigation of new problems such as the cause of profuse salivation while grazing, nitrate poisoning, etc.

Included in research on nutrients are basic studies on carotene and its conversion to vitamin A, the various levels and kinds of protein that result in maximum milk secretion, and the factors affecting the absorption and utilization of minerals including the role of less well understood minerals such as selenium, molybdenum and zinc. Other

studies seek to determine the kinds and quantity of fat a cow can tolerate, and the feasibility of giving cows tranquilizers, antibiotics or hormones.

Basic problems on calf feeding concern the nutrient value of filled milks, the minimum milk and fat requirements of calves, and the necessity of providing the young calf with liquid food which solidifies as soon as it reaches the true stomach. Dairy scientists are studying the prenatal as well as the postnatal nutrient requirements of calves. The value of pathogen-free calves on purified diets is being tested. Medicated feeds as well as antibiotics are added to the diets of very young calves, especially those receiving no colostrum. Nonpathogenic types of diarrhea are also being investigated. One station is studying the importance of the fat-splitting enzymes secreted in the oral cavity and their significance in fat digestion. Another station is determining the importance of vitamin A to the calf's growth, sight, manner and places of storage in the body. Still other stations are concerned with carbohydrate utilization and the synthesis of B-complex vitamins in the rumen. Blood values are also being studied more intensively and including determination of feeds likely to alter normal blood levels.

Most of the research on management practices, equipment and facilities is limited to information which can be gathered from herd records, such as the effect of length of dry period on the succeeding lactation, or the effect of early breeding on the health and lifetime production of high producing cattle. Probably the most elaborate current trial dealing with herd management is at the Pennsylvania station where three systems of handling cattle are under study, using separate barns and herds but as nearly as possible the same managerial ability. Effects of automation, machine milking, sanitizing, etc., will be reviewed in other sections.

The research in industry on dairy cattle nutrition is conducted primarily by the feed manufacturing companies. The largest portion of the work is involved with vitamin requirements and ration comparisons for calves with particular emphasis on milk replacers. Ration comparison as well as supplementation and feed additives trials are conducted with lactating cattle. The estimated activity in this field by industry amounts to approximately 60 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

There is considerable question concerning the most accurate method of evaluating and expressing the energy values of feeds, whether by means of total digestible nutrients, digestible energy, metabolizable

energy or net energy. An energy laboratory was established to study these methods as well as to inquire into the various fundamental metabolic factors which might affect the efficiency of feed utilization.

1. Effect of Stage of Maturity and Plane of Nutrition on Energy Values of Forage.

Early-cut alfalfa, late-cut alfalfa and late-cut orchard grass were harvested, pelleted and fed to nonlactating dairy cows at three planes of nutrition: 50% maintenance, 100% maintenance and ad libitum. A total of 104 digestibility trials, 108, 24-hour respiration and 84, 24-hour fasting respiration trials have been completed. While all the data have not been calculated, animal variation in ad libitum consumption of pellets was noted, but the plane of nutrition effects on apparent digestibility were small. The apparent digestibility of dry matter, organic matter, gross energy, nitrogen and carbon decreased with increased stage of maturity and the digestibility of all these constituents was less for orchard grass than for alfalfa cut on the same day. The average for all determinations in terms of digestible energy per lb. were for early-cut alfalfa 1217, late-cut alfalfa 1021, late-cut orchard grass 991. Ad libitum consumption as percent of maintenance was 144, 151, and 121, respectively. (AH h2-8)

2. Carbon Analysis.

Using the conventional wet combustion carbon train, 892 samples analyzed in the above experiment required the time of one person for 112 days. A Leco induction furnace and carbon determinator were obtained by which the same data could be obtained in 18 days. It was found necessary to alter the catalyst for the combustion of the samples of biological material. These investigations have resulted in the development of an accurate method for rapid carbon analysis with a considerable saving of time, since carbon analyses are so important in energy balance trials. (AH h2-8)

3. Preservation of Excreta.

Adequate methods for the preservation of excreta without losses of volatile materials for analysis at a later date are important in energy balance trials.

The results of studies on freezing, canning and drying as methods of preserving bovine feces for chemical analysis have been summarized. Analytical results indicated that there were no detectable differences in the gross energy of feces which could be attributed to method of preservation. However, highly significant ($p < 0.01$) losses of nitrogen occurred when feces were dried, regardless of the temperature (61-80° C.)

or length of time (6-48 hr.) used to dry the samples. Canning and freezing were equally effective as a means of storing the samples without nitrogen loss. Canning was found to be a convenient means of storing samples at room temperature for extended periods. In general, it may be concluded that samples of feces may be stored for nitrogen, carbon and gross energy analyses by freezing or canning, and that gross energy determinations may be made on dried, pulverized samples. Freezing would be the method of choice for urine. (AH h2-8)

4. Absorption of Methane and Carbon Dioxide from the Rumen.

When feeds in the rumen undergo bacterial fermentation, methane and carbon dioxide gases are produced. In the metabolism of nutrients within the body tissues carbon dioxide is also produced. In making certain calculations in energy balance trials, it is necessary to know the proportion of carbon dioxide which is produced in the body proper and the portion produced by the fermentation of feed in the intestinal tract.

In order to study this problem, tracheostomized Jersey cows were used, in which the eructed gas and respiration gas from the lungs could be separately collected. The cows were fed two different rations, a ration of forage and a feed lot bloat-producing ration (61% barley, 22% alfalfa, 16% soya oil meal and 1% salt). Carbon dioxide absorption from the rumen was calculated from the radioactivity in the expired and eructed gas during the continuous infusion of C^{14} -labelled carbonate into the rumen. When hay was the ration, 0.93 liters of methane per hour were produced before feeding with 73% being absorbed. In the same order, when grain was fed, the figures before feeding were 2.19 l./hr. and 51%, and after feeding 6.25 l./hr. and 20%. When hay was fed, 5.5 l./hr. of carbon dioxide were produced before feeding with 89% being absorbed. After feeding, 17.4 l./hr. were produced with 67% being absorbed. When grain was the ration, the figures were 5.4 l./hr. and 69% absorption before feeding, and 24.9 l./hr. and 45% absorption after feeding. Not only does the proportion of gas absorbed through the rumen depend upon the time of feeding, but it is also noteworthy that less carbon dioxide was absorbed through the rumen wall when the cows were fed the grain ration than when fed the hay ration. The data raise several questions which need further clarification and point out that the amount or proportion of CO_2 absorbed is dependent upon the type of ration fed. (AH h2-8)

5. Chemical Methods for Determining the Nutritive Value of Feeds and Forages.

These studies during the past year include the investigation, choice and development of suitable chemical methods to be applied in the analysis of forages for the comparison of chemical composition with digestibility.

Continued progress has been made in applying the use of detergents in the formulation of suitable procedures for fiber and lignin. Early in the year it was determined that a quaternary detergent, hexadecyl-trimethylammonium bromide (CTAB), was superior to other detergents in the solution of proteins from the dry matter residue of forages. Utilizing this principle, a simplified and rapid procedure for fiber (termed acid detergent fiber which includes the lignin) was developed. A simplified lignin method was also developed. Detailed studies have been made in regard to the effect of concentrations of the CTAB detergent, acid concentration and time of boiling upon the yield of acid detergent fiber and its composition in respect to protein and lignin. The adopted procedure consists of refluxing with normal sulfuric acid containing two percent CTAB for one hour. Preliminary solvent extraction has been eliminated by the addition of two ml. of decahydronaphthalene to the reflux mixture. The lignin analysis is made upon the acid fiber residue with 72% sulfuric acid.

Results obtained with various forages show that acid detergent fiber residue consists chiefly of lignocellulose with a small amount of protein which seems to be firmly bound to the fiber. A correlation of -0.75 was obtained for the acid detergent fiber with digestibility of the dry matter. For lignin separately, the correlation with digestibility was -0.92. The corresponding correlation for crude fiber was -0.71. Sixteen comparisons were available for the lignin correlation, and 18 for those of the acid detergent fiber and crude fiber, including both grass and legumes species. The lignin obtained appears indigestible on four feed-feces comparisons. Further studies on the composition of lignin will have to be made before final conclusions can be made on the relationship between different lignin methods. With such a high negative correlation between lignin and digestibility (-0.92) for both grasses and legumes, it appears that the proposed procedure is quite promising.

Studies on the composition of the acid detergent fiber residue reveal that it contains on the average about 10% of the total feed nitrogen. This nitrogen appears to have a low digestibility and the amount remaining in the residue is associated negatively with digestible crude protein and positively with the amount of nitrogen undissolved by pepsin. The detergent is considerably more efficient in the removal of nitrogen from plant tissue than commonly used pepsin. Acid detergent removed in one hour a greater proportion of the nitrogen than pepsin digestion removed in 40 hours. Studies on the effects of heating and drying show that heating above 80° C. renders the protein less soluble in either detergent or pepsin. This observation is also associated with low in vivo protein utilization. This procedure may prove useful for determining the effect of heat application on the digestibility of feeds. (AH h2-6)

6. Agricultural Chemicals in Milk.

a. Effect of Oral Administration of Diazinon to Cows and Its Excretion into Milk.

At Beltsville a 25% diazinon wettable powder in capsules was fed to lactating dairy cows at rates of 0, 10, 50, 100, 250, and 500 p.p.m. of the dry matter intake per day. The milk fat separated from the milk was analyzed by a method published by the Geigy Chemical Co. No diazinon per se was detected in the milk fat. While some breakdown products of diazinon might be secreted into milk, it must be concluded that no diazinon as such is secreted into milk. (AH h2-9)

b. Stability of Diazinon in Silage.

At Tifton, Georgia, immature chopped rye grass was sprayed with emulsifiable diazinon in water at the rate of 10 and 100 p.p.m. of fresh forage. The silage was then packed and sealed into quart glass jars. The jars were opened at 5, 12, and 22 days. The results showed that there was a gradual destruction of the diazinon in the silage. After 22 days only about 3% of the diazinon remained in the silage. It can be concluded that after a reasonable period of storage, diazinon as such would not be present in silage and the silage could be fed to animals. (AH h2-9)

c. Dimethoate Secretion into Milk.

At Tifton, Georgia, a field of corn was sprayed with 0, 4, 8, and 16 ounces of dimethoate (in 100 gallons of water) per acre at 100 psi's pressure. After allowing the spray material to dry on the plant, the corn was harvested as silage and stored in ground stack silos covered with 4 mil polyethylene plastic weighted down with sawdust. There were three replications for each insecticide level. After nine weeks storage, 50% of the dimethoate was still present in the four-ounce treatment, the lowest level of treatment. During the 28-day feeding test the dimethoate averaged 1.2, 2.6, and 5.3 p.p.m. in the silage. The silage had a somewhat pungent and disagreeable odor related to the levels of dimethoate used. The odor affected the intake of silage and the cows were erratic in acceptance of the silage. A detectable amount of dimethoate appeared in the milk (0.01 p.p.m.) 14 days after feeding began. None was detectable 14 days after feeding was terminated. One animal fed the 16-ounce treated silage developed toxic symptoms and had to be slaughtered. It appears that dimethoate can remain in corn silage and be excreted into milk. However, from data collected with other plant material, it is probable that if dimethoate were applied to plants in the field two weeks before harvest, most of it will have disappeared. (AH h2-9)

B. Forage Evaluation and Utilization

1. Silages.

a. Nitrate Relationships in Silage.

- (1) Effect of nitrogen fertilization on quality and feeding value of silage.

The use of nitrogen fertilizer has become a widely accepted method of increasing both yield and protein content of grass forages. An increase has been observed in digestible energy as well as digestible protein of grass hays with nitrogen fertilization. Information on the ensiling of nitrogen fertilized grass crops is not available. A direct comparison was made of storage losses, chemical quality and feeding value of first-cutting orchard grass direct cut harvested as unfertilized and fertilized forage (400 lbs/acre ammonium nitrate) stored in two upright silos. Under the conditions of this experiment the application of nitrogen 15 days prior to harvest resulted in greater loss of stored dry matter (15.1% vs. 21.5%), higher protein content (14.1% vs. 25.2%) and a decidedly inferior quality of silage (pH 4.0 vs. 5.0) ammoniacal nitrogen as protein (7.7% vs. 21.7%) and a higher butyric acid content (0.2% vs. 2.2%). Despite the quality differences in the silage, they were about equal in feeding value.

- (2) Effect of nitrogen and molybdenum fertilizer on silage.

The importance of molybdenum in coenzyme systems for reduction of nitrate to ammonia in plants suggested that a deficiency of this element might limit the reduction process in highly fertilized orchard grass and result in nitrate accumulation in the plant. Four treatments consisting of all combinations of 0 or 800 pounds of ammonium nitrate per acre and 0 or 1.0 pounds of sodium molybdate per acre were applied July 14 in three replications to a third cutting orchard grass field making a total of 12 plots. Neither accumulation of nitrate, crude protein nor reducing sugar content of the orchard grass was affected by molybdenum fertilizer with or without nitrate fertilization. Some of the forages which were ensiled in quart jars showed quality characteristics which were contrary to previous findings. For instance, low protein forage produced silage of higher butyric and lower lactic acid content than did high protein forage. Grinding adversely affected chemical quality in low protein forage but had the opposite effect on high protein forage. Further fundamental observations on these effects are required to explain them.

(AH h3-3)

Other work with ensiling high nitrate orchard grass forage showed a considerable reduction in nitrate content during the first three days after ensiling. It was also noted that if there was an increase in pH of the silage a further decrease in nitrate was noted. Such would be inimical to the preservation of high quality forage. Addition of sugar with a rapid reduction in pH permitted more nitrate to remain in the silage. (AH h3-1)

(3) Nitrate reducing organisms in silage.

A study was made on the nitrate reducing enterococci isolated from silage. This particular group was of interest because they have previously been classified on the basis of being unable to reduce nitrate. The results showed that media composition (nutrition), temperature, pH and oxygen had considerable influence on growth and reduction of nitrate by this group of organisms. Steps of reduction were examined and it was shown that the strains were capable of reducing nitrate to ammonia. Organisms of this type may be important in reducing high levels of nitrates in forages which have been shown to be toxic to animals. (AH h3-2)

(4) Nitrogen fertilization and silage bacteria.

In data collected elsewhere in this work project, it is pointed out that nitrogen fertilized forages are more difficult to ensile than nonfertilized forage. Studies were also conducted on the numbers and types of bacteria present in the two types of silage as well as to investigate the bacteria which will reduce nitrate. The results showed that while nitrogen fertilization caused considerable change in the chemical composition of the harvested forage, the numbers and types of bacteria present in the silage were not greatly changed. These observations confirm previous data that except for the anaerobic sporeformers the bacterial population in silage is not greatly altered in numbers and species indicating a rather stable situation. Bacteria were present in the silage population which could reduce nitrate suggesting that this is one pathway by which the nitrate reduction takes place. (AH h3-2)

b. Harvesting Methods & Storage Structures.

(1) Measurement of degree of laceration of forage

It has been demonstrated that laceration or bruising of plant tissue prior to ensiling aids in the preservation of silage in small laboratory silos. However, in experimental work there has been no objective method of measuring the degree of laceration. From a suggestion published from England that specific gravity of the forage before and after laceration would be a good index, an apparatus was

constructed for this purpose. For instance, the specific gravity of the forage cut by a field chopper was 0.79, for a Letz chopper 0.8, for a Silorator 0.84, and for a food grinder 1.05 (AH h3-1)

(2) Effect of laceration on silage quality.

Some data collected several years ago at Beltsville on a small-scale basis with quart jars and 4' x 8' silos indicated that bruising or laceration of forage at the time of ensiling improved the quality characteristics of the resulting silage through more favorable fermentation conditions. A large-scale trial was conducted at Lewisburg, Tennessee, in cooperation with the University of Tennessee on the effect of bruising of grass legume silage as against chopping and storing in large silos. Comparisons were made on dry matter consumed, chemical composition and feeding value in terms of consumption of dry matter and milk production of the two silages. No significant differences were noted between any of the factors measured except for ammoniacal nitrogen expressed as crude protein. The values were 3.2% for control silage and 2.5% for the bruised silage. Under the experimental conditions at Tennessee, bruising in a practical large-scale operation caused little improvement in the quality or feeding value of the silage. The experiment is being conducted a second year. (AH h3-9)

(3) Chopped and ground forage.

Exposure of orchard grass forage to air for 8 hours after chopping or grinding but before ensiling in quart jars produced increased counts of anaerobic sporeformers at 60 days after ensiling as compared to forage ensiled with a minimum (0 hours) of exposure. This increased count, which has been associated with decreased chemical quality, developed during the period following ensiling. (AH h3-2)

(4) Use of tower and bunker silos.

At Willard, North Carolina, corn and Sart Sorghum crops were harvested and stored in two bunker and two tower silos. More corn silage dry matter was preserved in tower than the bunker silo (87.9% vs. 74.3%). Likewise, more Sart dry matter was preserved in the tower silos than in the bunker silo (69.5% vs. 65.9%). Under the conditions used at Willard, the tower silos were more efficient in the preservation of dry matter than the bunker silos.

At Beltsville, Maryland, corn silage stored in a bunker silo showed a dry matter loss of 12% which is as good as would be expected in a tower silo. The silage was packed with a bulldozer, sealed and weighted with plastic and sawdust. Silo capacity was less than previously observed when packing was done with a wheel type tractor. (AH h3-3) (In cooperation with the Agricultural Engineering Research Division).

(5) Production of low-moisture silage in tower silos.

Because high dry matter silage is consumed in greater amounts than silage with a low dry matter content, an experiment was run to determine whether high dry matter silage could be stored in tower silos. High dry matter silage from first-cutting alfalfa was successfully stored in two conventional tower silos. Some forage contained 65% dry matter when stored but the average for the silos was about 42%. A dry matter recovery of 95% was obtained as silage and no excessive heating or spoilage was observed as a result of fine chopping, careful distribution, tramping and top sealing. The resulting silage was equal in feeding value to barn-dried hay made at the same time from the same crop when fed to milking cows and dairy heifers. The results indicate that a satisfactory harvesting and feeding program can be developed with high dry matter silage as the only forage.

(6) Preservation of wilted alfalfa silage in bunker silos.

In previous work at Beltsville, crops stored in bunker silos have been direct cut so that the full initial moisture content could be utilized as an aid to consolidation and air exclusion. Silage containing up to 40% dry matter was successfully stored in a bunker silo and 87% of the dry matter was recovered for feeding. Although spoilage was well controlled by sealing with plastic sheeting, each successive layer from the top in the silo was more efficiently preserved. The exposure of forage which occurred when filling was stopped during the night and during one day of bad weather resulted in distinctly lower chemical quality compared to portions which were promptly protected from the air. These observations support the idea that rapid filling and sealing is a good practice to follow. The results also demonstrate that wilted silage can be stored in a bunker silo when proper packing and sealing the silo is accomplished. (AH h3-3)

(7) Effects of water added after wilting on silage quality.

This work was undertaken to estimate whether water added to wilted forage at the time of ensiling would have any effect on quality of the resulting silage. This would also simulate a field situation where wilted forage was rained on in the field and provide information as to the necessity of removing the added water (rain) before ensiling. The possibility also existed that the quality of silage could be improved if better packing and consolidation could be achieved by adding water without adversely affecting silage fermentation. Results indicated that the improvement of silage fermentation by wilting is related to the lower moisture level per se and that the addition of water at the time of ensiling tends to negate these improvements.

Limited acceptability trials showed that wilting up to 65% dry matter resulted in increased consumption rates compared to wilting to 48%.

(8) Silages in the Puget Sound area.

This project is conducted in cooperation with the Washington Agricultural Experiment Station at Pullman, Washington. Because of climatic conditions and the difficulty of producing wilted silage in the Puget Sound area, methods of utilizing direct-cut high moisture silage were investigated. Four groups of cows were fed two levels of grain and two levels of hay with the high moisture silage. There were no differences in milk production for the levels of hay feeding (13.3 lbs. per day vs. 6.9 lbs. per day). There were differences in milk production for high and low level of grain feeding (20 lbs./day vs. 9.5 lbs./day). The difference in milk production was 3.8 pounds milk per day. There was a higher concentration of protein and solids-not-fat in the milk produced on the higher levels of grain feeding. Under the conditions of the Puget Sound area where direct-cut silage is made, it may be necessary to feed more heavily on concentrates to obtain an optimal level of milk production. (AH h3-7)

c. Preservatives.

(1) Tylosin (an antibiotic).

Tylosin is an inhibitory substance obtained from Streptomycin. It is especially active against sporeforming anaerobes. The sporeforming anaerobes are largely responsible for the production of poor quality silage. To be effective in silage the antibiotic must inhibit the growth of sporeformers but permit the growth of lactic acid bacteria which produce the acid necessary to preserve the silage.

In experiments with pure media, it was demonstrated that the lactic acid producing bacteria were able to grow in all concentrations of tylosin (0.5 to 2 p.p.m.) but the sporeforming clostridia were unable to tolerate the lowest level used (0.5 p.p.m.). This suggested that the antibiotic showed differentiation between the two species of bacteria and that its application to silage making might be useful.

The next step was to study the effect of the antibiotic when introduced into silage slurries under various conditions. Slurries under oxygen, nitrogen, with and without added inoculum of sporeformers and different levels of antibiotic were studied. The results showed that under a nitrogen atmosphere, a condition comparable to actual silo conditions, tylosin was effective in permitting a reduction of the pH of the slurry (control pH 5.07, 1 p.p.m. tylosin pH 4.32, 5.0 p.p.m. tylosin pH 4.20). Under oxygen there was evidence of destruction of tylosin. These results gave encouragement to proceed one step further by use of quart jars and 4' x 8' silos.

Forage ensiled in quart jars and 4' x 8' silos showed that the tylosin permitted a decrease in pH which resulted in the production of good quality silage.

The results to date are quite encouraging on the use of tylosin as a silage antibiotic and should be pursued further under more acute stress situations. (AH h3-2)

(2) Silotracin.

From time to time antibiotics have been proposed as a silage preservative. Direct-cut third cutting alfalfa was ensiled in 4' x 8' silos. Silotracin was added to one silo at the rate of 5 pounds per ton of forage. The fresh cut forage contained 20% dry matter and 19% protein on a dry basis. Both silages were of good quality. Silotracin showed no positive effect but had no deleterious effect. (AH h3-3)

d. Feeding Value of Corn and Sorghum Silages.

At Willard, North Carolina, one comparison of corn and Sart Sorghum silages using two levels of protein in the concentrate ration showed that there was greater consumption of corn silage and more milk was produced (24.4 lbs. vs. 21.5 lbs. FCM). The cows fed the 22% protein concentrate ration produced more milk than those fed 18% protein (25.3 lbs. vs. 23.5 lbs. FCM). There was no difference between the Sart Sorghum silage groups in this respect. Heifers fed the corn silage with 3.0 pounds of grain out gained those fed the Sart Sorghum silage. In digestibility trials with steers there was no difference in digestibility of dry matter between the two silages. In a further experiment comparing corn, Sart and Hegari silage, corn and Hegari were about equal in feeding value with Sart less valuable. The results show that corn silage and Hegari are more acceptable than Sart silage to dairy cattle and they produced more milk and more gain. (AH h3-8)

e. Biochemical Studies.

(1) Sugar-protein ratio in silage.

In the fermentation process in the silo, certain bacteria convert the readily available sugars and carbohydrates to organic acids such as lactic, acetic, formic and propionic which increases the acidity of the silage to a low pH so that the forage will be preserved. On the other hand, some bacteria break down the protein and nonprotein fractions in the silage to ammonia and other nitrogenous products. The ammonia produced tends to neutralize the organic acids and increase the pH which is detrimental. Also, some of the bacteria

change the lactic acid to butyric acid which also permits an increase in pH and results in poor quality silage. It would appear that some balance of sugar and protein is required in the fermentation process and that high protein forage is more difficult to ensile because it requires more readily available sugar for the formation of acids. Using quart jar silos with 46 orchard grass silages, a good correlation was observed between sugar and protein content of the forage and the resulting pH of the silage.

When the sugar content of the forage ensiled was 13.5% of the protein content (4.28% sugar and 31.5% crude protein), the resulting silage had a pH of 7.05 with 16.5% ammonia N expressed as protein. When the sugar to protein ratio was increased to 37.5% by the addition of sugar, the pH of the silage was 4.1 with only 2.0% ammonia N expressed as protein.

These fundamental relationships require further study and do offer some promise of being useful in the ensiling of high protein crops.
(AH h3-1)

(2) Mineral relationships in silage.

It has been suggested that the minerals present in the forage at the time of ensiling might have some affect on the fermentation process. Salts of potassium, magnesium, manganese, copper, zinc, and cobalt were dissolved in water and applied to forage at the time of ensiling. Preliminary data in small silos indicate that the minerals produced a silage with a lower pH and a higher lactic acid content than the untreated forage. (AH h3-1)

(3) Protein determination in the presence of nitrate.

In the determination of the protein content of forage by the Kjeldahl procedure the nitrogen in the nitrate would be determined as protein resulting in considerable error. It was found that by the addition of 70 ml of water and 6 grams of sodium chloride the nitrates would be removed from the digestion mixture, before the addition of concentrated sulfuric acid and mercuric oxide. The effect of the presence of other constituents is being studied before the procedure will be recommended. (AH h3-1)

(4) Separation of amines.

In connection with the problem of acceptability of silage by cattle, it has been suggested that the amine concentration in the silage might be a factor to be considered. However, no very simple method of analysis of amines is available. A method was

developed using partition chromatography with celite columns. The columns are eluted with varying proportions of acetone and hexane. Ammonia and trimethyl amine were easily separated by the use of the column. One sample of silage was found to contain 0.63% trimethyl amine. The new method will materially aid further studies on elucidation of factors concerned with silage acceptability. (AH h3-1)

2. Pastures.

a. Coastal Bermuda Grass for Dairy Cows.

In the coastal area where Willard, North Carolina, is located, the usual pasture grasses do not produce well. The answer to this problem has centered around the development and use of annual crops for this purpose. With the advent of Coastal Bermuda Grass as a perennial grass for pasture use with beef cattle, it was felt that the grass should be studied for its use with dairy cattle. A comparison was made between rotationally grazed Coastal Bermuda Grass, rotationally grazed Starr Millet and ad libitum feeding of small grain-crimson clover silage. Jersey cows producing about 40 pounds of milk per day declined at the rate of 12.9% per month on the Bermuda Grass, 10.9% on Starr Millet and 20.5% on the small grain-crimson clover silage. Thus, the Coastal Bermuda Grass compared favorably with the Starr Millet and warrants further investigation. (AH h3-10)

b. Stocking Rate of Dairy Cows on Orchard Grass Ladino Pasture.

The effects of intensive, moderate and liberal utilization of rotational pastures on the productivity of pastures and animals was continued at Beltsville in 1961 for the second consecutive season.

In a statistically designed experiment, the different degrees of intensity of grazing were obtained by keeping an equal number of cows on plots of different size (1/2, 3/4 and 1 acre) for the same number of days. This resulted in very intense nearly complete utilization of the 1/2 acre plots, moderate utilization of the 3/4 acre plots and a low or liberal level of utilization of the 1 acre plots.

Analysis of the 1960 data showed that per acre animal production under moderate and liberal utilization was about 80 and 70%, respectively, of that obtained under intensive utilization. The animals on intensive, moderate and liberal regimes obtained .70, .47 and .37 pounds of TDN, respectively, from each pound of dry matter available to them based on field samples. Thus, it was shown that utilization management has a powerful influence on the productivity of pastures.

The effects of these regimes on daily production of tester cows were in the expected direction with more intensive utilization being

associated with lower production per cow per day. However, because of the large differences in individual cow response to the same treatments, average treatment differences for the season were not statistically significant. These data indicate that a much larger or more homogeneous cow population is required to demonstrate significantly different effects on per animal production at these levels of utilization stress.

Intensive utilization resulted in a small reduction of the digestibility of the organic matter consumed and a one-third reduction in the daily intake of digestible organic matter as compared to liberal management. Moderate utilization produced an intermediate change in both of these values. When it was assumed that animal determined values for seasonal dry matter consumption per acre were correct, the values estimated from field samples yielded an under estimate of 5% and over estimates of 12 and 30% for the intense, moderate and liberal systems, respectively. This indicates a serious interaction of methods of estimating dry matter consumed and intensity of utilization.

The detrimental effects of intensive utilization on regrowth vigor of the pasture plants were increasingly apparent as the 1961 season progressed. This resulted in a lower production of available forage per acre under this regime. It appears at present that milking cows may be more adaptable to nearly complete pasture utilization than are the pasture plants.

Data obtained so far indicate that improved pasture can be more thoroughly utilized than is generally thought to be the case without a prohibitive reduction in per animal production and with a marked increase in per acre production. However, this intense utilization may have to be coupled with very short grazing periods to accommodate for the strength and recovery of the pasture plants. (AH h3-18)

C. Nutritional Requirements

1. Maintenance Requirement for Stanchioned Nonlactating Cows.

The maintenance requirement found for stanchioned nonlactating dairy cows in this investigation was approximately 13.00 pounds alfalfa dry matter per 1,000 pounds liveweight. The TDN value of the predominant hay used in this trial was found to be 56.5% and the digestible energy content was 57.5%. Thus the maintenance requirement was 7.35 pounds TDN/1000 pounds. This is within the ranges of other data reported which indicates that one pound TDN for maintenance was equal to 58% and 103% of the therms of metabolizable and net energy, respectively.

The values calculated by Brody and Gaines were obtained from production record data by mathematically partitioning intake into that used for

milk production, maintenance and gain. The values so obtained of 8.2 and 9.9 pounds TDN per 1,000 pounds liveweight are higher than other values obtained by direct observations. Reasons for this are not apparent but may be due to methods of calculation or to a difference between "working" and "idle" maintenance requirements. The values reported in the literature for bulls were approximately 8.1 to 8.5 pounds TDN per 1,000 pounds liveweight which is somewhat above the values found for cows. (AH h2-4)

2. Maintenance Requirement During Winter and Summer Seasons.

The amount of alfalfa dry matter consumed from the last week in May to the first week in September was compared to that consumed from the last week in November to the first week in March for 15 cows with 21 observations during each season. Similar information on 3 cows fed 30.5% grain and 69.5% alfalfa was also obtained. The average weights during summer and winter seasons were practically identical. The net amount of feed consumed with no body weight change was practically the same in summer months as during the winter months when either of two weight change correction factors was used. The relationship between body weight and adjusted intake was calculated for both the summer and winter seasons and found to be practically identical using the 21 observations when cows were fed only alfalfa hay. The relationship found from data in summer was alfalfa D.M. for maintenance = $0.3958W^{.507}$ and for winter = $0.3966W^{.51}$. The calculated requirement for a 1,000 pound cow was 13.13 and 13.25 pounds alfalfa D.M. for summer and winter, respectively. These data indicate that the amount of feed required to maintain constant body weight was the same for summer as for winter seasons under the conditions of these trials. (AH h2-4)

3. Maintenance Requirement Before and After Ovariectomy.

The intake, body weight, and its changes for 3 cows fed alfalfa hay before and after removal of the ovaries were measured. Calculations showed that each cow required less feed to maintain the same body weight with no weight change after removal of the ovaries. (AH h2-4)

4. Maintenance Requirements of the Grazing Cow.

In order to gain further information on the maintenance requirements of grazing cattle, three cows were subjected to three treatments. In one treatment a cow was strip grazed. In a second treatment another cow was fed forage clipped from a similar adjacent area while tied to a feed manger in the pasture field, while in the third treatment a cow was fed the same clipped forage while being housed in a respiration chamber in an air-conditioned laboratory.

Each cow was rotated through all three treatments. The maintenance requirements by regressing heat production values to zero feed intake for a 1,000 pounds animal were 10.9 Therms for the grazing cow, 12.5 Therms for the stall-fed pasture cow and 10.8 Therms for the animal in the air-conditioned laboratory. While the figures obtained are somewhat higher than those reported by Armsby (6.0 Therms), it should be pointed out that these data were obtained using fresh green forage while those of Armsby were obtained using rations of dry forage and low concentrates. The results suggest that the requirements for maintenance for a grazing cow are no greater than for a stall fed animal. The high figure for the pasture stall-fed animal probably denotes the tension of being confined to a stall while her contemporaries were grazing close by. (AH h2-7)

5. Replacement Values for Forages and Concentrates for Maintenance.

The replacement equivalents of grain and hay are not definitely established. In order to obtain some information on the replacement equivalents of these two feeds, adult, nonpregnant cows were maintained on rations having different hay to grain proportions. Eight Holstein cows were fed a ration having 1.0:0, 3/4:1/4, 1/2:1/2, and 1/4:3/4, proportion of alfalfa hay to concentrate, respectively, for periods of 120 days in an experiment of a Latin square design. Data on the last 90 days of each period were used. Subsequently, 4 of the cows were fed only the concentrate (37% soybean meal, 63% corn) for a period of over 180 days. In another trial 4 Jersey cows were fed alfalfa and concentrate in porportions of 1:0, 2/3:1/3, 1/2:2/3, and 0:1, respectively, for periods of 180 days each.

The average adjusted consumption, body weights and replacement equivalents were calculated. The average body weight for the Holstein cows decreased when the proportion of dietary concentrate increased. No correction for these changes was made when the replacement equivalents were calculated. The hay replacement equivalents for 100% grain were calculated from the averages of the animals used on this diet and weight had to be adjusted with the 2 Jersey cows using W.⁷.

These calculations using data on the Holstein animals indicate that 1 pound of hay is worth about 55% of the value of 1 pound of the concentrate used. This calculated replacement equivalent was reasonably near the same for all treatment comparisons made. Data on the Jersey cows gave a similar replacement value but the value was not as repeatable between all treatment comparisons.

The replacement values obtained from these trials approximate the relationship of these two feeds when expressed on an estimated net energy (ENE) basis. The TDN and the digestible energy content was

determined using three of the cows and found to be 56.54% and 57.51%, respectively, for the hay and 82.71% and 84.64%, respectively, for the concentrate mixture used in these trials. Thus, the hay was worth 68% of the concentrate mixture when compared on the determined TDN or digestible energy basis. The ENE was calculated from the TDN value according to the formula of Moore et al., and on this basis the hay was worth 54.7% of the concentrate mixture.

It appears that the replacement values of a hay and a concentrate for purposes of maintaining body weight in dairy cows is best expressed on an ENE basis rather than on a TDN basis. (AH h2-4)

D. Calf Feeding

1. Effect of Method of Conservation on Forage Consumption of Dairy Heifers.

Alfalfa harvested simultaneously from the same field as hay, wilted silage higher in dry matter than the usual wilted silage (43-46% DM) or as direct-cut silage during 2 different crop years was fed for 2 to 3 months to growing dairy heifers 7 to 19 months of age. For each crop year there was little difference in rates of gain or dry matter intake or in efficiency of gain for heifers fed hay or wilted silage (43-46% DM). Heifers fed direct-cut silage had lower rates of gain, dry matter intake and efficiency.

In further studies, second-cutting alfalfa was harvested from the same field and preserved as direct-cut silage, wilted silage or haylage. Hay was harvested one week later from the same field. The dry matter content of the feeds was 20.8%, 34.9%, 49.8%, and 88.7%, respectively. The intake of dry matter per 100 pounds body weight for 8 days was 2.14, 2.67, 3.28, and 2.86. These data again add further weight to the evidence that one factor which controls dry matter intake of silage is the dry matter content of the crop at the time of ensiling, since the dry matter content of the feed is closely related to dry matter content of the crop at harvest. (AH hl-1)

2. Effect of Concentrates and Hay on Growth of Heifers Fed Wilted Silage.

Three methods of supplementing the wilted silage ration have been studied. Concentrates were fed at two levels, 3 pounds and 4 pounds per day and hay was fed ad libitum with the usual amount of milk and grain.

The results show that the group fed wilted silage and hay ad libitum compared to the Beltsville growth standards, were 96% of normal, those fed 3.0 pounds grain 102% and those fed 4.0 pounds 107%, while

those which received wilted silage as the only feed after 8 months of age were 81% normal. These results to date show that where wilted silage is used as the only forage after 8 months of age, that hay fed ad libitum or 3 pounds of grain per day will produce normal growth. (AH hl-1)

3. Effect of Drying High pH Silage on Dry Matter Intake of Heifers.

Previous data have shown that the reduction of the water content of silage by drying did not affect dry matter intake. The silages were good quality with a low pH, (4.5 or below). Last year a poor quality silage was available with a pH of 7.03. The silage was fed to one animal before and after drying with a dry matter intake of 7.3 pounds in the wet state and 11.0 pounds in the dry state. By drying silage with a pH of 7.03, volatile bases were probably evaporated. For instance, the ammonia content of the wet silage was 2.9% while in the dry silage it was 0.1%. These data, while limited, suggest that the presence of volatile bases in the silage may be one factor affecting acceptability. (AH hl-1)

4. Dry Matter Content and Intake of Orchard Grass Silage.

Previous experiments on the intake of silage dry matter by dairy animals has been with alfalfa silage. Orchard grass silage cut from the same field on the same day and containing 25.5 and 37.0% dry matter was compared in reversal trials of 11 days duration with dairy heifers. The results checked the previous data with alfalfa silage in that more dry matter was consumed when the silage contained 37.0% dry matter. (AH hl-1)

5. Use of Rabbits to Study Effect of Silage on Growth.

In order to hasten the study of the various factors which affect the acceptability of silage by dairy heifers, a study was made of the use of the rabbit for this purpose using growth as a measure of acceptability. The results showed that the rabbits responded in the same way as heifers. For instance, they grew considerably more on hay than on silage made from the same field.

In further experiments, I. Alfalfa silage (35% D.M.), II. Pressed silage cake (55% D.M.), III. Pressed silage cake plus the expressed silage juice (30% D.M.), IV. Chopped alfalfa hay and V. Chopped alfalfa hay plus expressed silage juice was fed to five groups of four rabbits each. The growth of groups I, II and III were similar in that they lost weight. Groups IV and V gained weight. The results show that the juice expressed by the use of a Carver press did not contain the factor which causes depression in D.M. intake in sufficient concentration to affect dry matter intake when added to a hay diet. (AH hl-1)

6. Magnesium and Cardiovascular Changes.

Where whole-milk-fed calves are not supplemented with magnesium, marked calcification of the cardiovascular system occurs. Workers elsewhere have postulated that the calcification was due to a deficiency of vitamin E in the whole milk diet. Supplementation of the whole milk diet with 50 mg. of alpha tocopherol per 100 pounds body weight did not prevent the cardiovascular lesions. While the extent of calcification may be affected by other minerals in the diet, it is concluded that magnesium is the specific deficiency which causes calcification in the cardiovascular system in calves. (AH hl-2)

7. Availability of Magnesium to Milk-Fed Calves as Affected by Various Factors.

Previous data from Beltsville has shown that the level of phosphorus in the diet of milk-fed calves had an effect on the level of magnesium in the blood serum. In the light of this observation it was decided to determine whether manganese would counteract the lowering effect of phosphorus on blood serum magnesium. When 0.43 gm. P/lb. milk was added as KH_2PO_4 blood serum magnesium values decreased more rapidly than where whole milk was fed with no supplementation. When 0.03 gm. Mn/lb. milk was added to whole milk, blood serum magnesium values decreased less rapidly than in calves fed whole milk or whole milk plus phosphorus. When both phosphorus and magnesium was added, the magnesium counteracted the effect of the phosphorus in lowering serum magnesium values. These results indicate that when calves are on a suboptimal level of magnesium (whole milk) the addition of phosphorus aggravates the situation and that manganese and additional magnesium counteract the effect of the phosphorus.

The addition of sodium or potassium bicarbonate did not prevent the decline in blood magnesium of whole milk-fed calves. The possible relation of these observations to grass tetany should be investigated. (AH hl-2)

8. Purified Diets for Calves.

For some time attempts have been made to develop suitable synthetic diets for calves so that it would be possible to produce single uncomplicated deficiencies by removal of a single nutrient such as a vitamin or mineral. Such a diet has been developed at the North Carolina Station suitable for sheep. The same diet is being tried with calves at Beltsville. Growth to 90 days of age has been about 80% normal, which is quite good for such a diet. (AH hl-3)

9. Activity of Vitamin A Acid.

It has been suggested that vitamin A acid can fulfill some functions of the vitamin A ester or alcohol but will not replace Vitamin A in the visual purple cycle in the eye. It was found with one calf, that the acid would decrease the spinal fluid pressure caused by vitamin A deficiency. It would thus appear that the acid form can perform the same function as the ester or alcohol form of vitamin A to control spinal fluid pressure in calves. Further data should be collected. (AH h1-3)

10. Raising Calves on Pasture.

In New Zealand a system of raising calves from a few days after birth on limited milk feeding and pasture has been developed. A comparison was made at Willard of rearing calves in the barn on milk, starter and hay compared to a similar group raised on milk, starter and pasture. The pasture sequence is of interest and was as follows: Ladino clover-fescue mixture in April and May (60 days), Starr Millet in June, July and August (72 days), some Coastal Bermuda also in August (20 days), soybeans in September and October (34 days), Ladino clover fescue in October (16 days) and small grain-crimson clover October through January. The pasture group gained more rapidly than the barn-fed group with gains up to 1.0 pounds per day to 122 days of age and up to 1.5 pounds from 112 days of age to 252 days of age. The preliminary results are very encouraging. (AH h3-11)

E. Management Practices, Equipment and Facilities

1. Hand Versus Machine Milking.

The study to determine the relative merits of hand and machine milking in relation to total production, persistency and mastitis was completed.

Forty first lactation Holstein cows were paired prior to freshening and assigned at random to each milking system. In the second lactation both groups were machine milked. Thus it was possible to evaluate the effects of the two milking systems in the first lactation, as well as changes from the first to second lactation when cows were milked by machine in both and when cows were milked by hand in the first lactation and by machine in the second.

During the first lactation, the hand-milked group exceeded the machine-milked group by 985 pounds of milk and 41 pounds of butterfat per cow. These differences approached significance. The hand-milked group was significantly more persistent than was the machine group (.84 vs. .79). The variation among cows in the machine group for both milk and persistency was also greater than for the hand-milked cows.

During the second lactation when both groups were milked by machine, no differences were found in total yield, standard deviation of yield or persistency.

Sixteen hand-milked cows had both first and second lactations. The standard deviation of milk yield increased by 2,030 pounds when these cows were machine-milked. This indicates considerable variation among the hand-milked group in their response to machine milking, and suggests the change to machine milking adversely affected some cows. In fact three of these cows produced less in their second lactation than they did in their first. Also three of them dried off before completing a 305 day lactation. There was a significant decrease in persistency of 15% between the two lactations, which is approximately 5% greater than is normally expected. In addition there was a significant increase in the standard deviation of persistency.

Eighteen machine-milked cows had both first and second lactation. There was a significant increase in total yield between the first and second lactations. This increase (+2,209 lbs.) was greater than the increase between the first and second lactation of the hand-milked cows (+1,424 lbs.). The increase in the standard deviation was not significant. The 10% decrease in persistency between the two lactations was significant but in line with what is normally expected between the first and second lactations.

Repeatability estimates were determined for both total yield and persistency for the two groups. The repeatability of milk yield was 0.36 for those cows milked by hand in the first lactation and by machine in the second, as compared to 0.54 for those cows machine-milked in both lactations. The repeatability of persistency was 0.0 for those cows milked by hand in the first lactation and by machine in the second, and 0.11 for those cows milked by machine in both lactations; neither of which were significant. The estimates reflect the differential response of the hand-milked cows to machine milking.

Another objective of this study was to determine if systems of milking had any influence on the incidence of mastitis. Three of the twenty cows milked by hand in the first lactation showed clinical symptoms of mastitis. Seven of the twenty milked by machine showed clinical symptoms. Even if these differences were real, the incidence in both groups was too low and the number of animals too few to warrant testing for significance. In the second lactation, the incidence of mastitis was six out of sixteen and five out of eighteen for the two groups, respectively.

These results show an adverse effect on total production when cows are milked by machine as compared to milking by hand. They also show a large amount of variation among cows in their response to machine

milking. The results suggest that if changes occur in the milking systems during the period of an experiment appropriate corrections should be made before the production data are summarized. In view of present day practices this problem will probably be of no importance in future research. However, it has an important bearing on the analysis of data from breeding research that covers a period when such changes could have occurred. (AH g3-9)

2. Electrically Controlled and Operated Equipment for Reduction of Labor in Dairy Production.

In cooperation with the agricultural engineers, a comparison of labor and time was made between three systems of milking. These systems were: (a) A portable bulk tank, (b) a dump station and (c) a regular routine.

The portable bulk tank was a rectangular stainless steel vacuum tank capable of holding 150 gallons of milk. The milk was cooled by a $1\frac{1}{2}$ horsepower refrigeration unit attached to one end of the tank. The tank was mounted on wheels and was self-propelled by a $1/3$ horsepower gear motor and steered by a hand lever. Cows were milked directly into the tank by two milking units. Equipment for supplying vacuum to operate the milking machines was also part of the system.

The dump station consisted of a milk receiving vessel and a plastic pipeline with enough hose to transport milk 200 feet. This system operated under vacuum and required a releaser at the opening into the bulk milk tank.

The regular system followed the conventional practice of carrying the milk in pails to the milk house and dumping the milk by hand into the bulk tank. The milk house was located an average distance of 50 feet from the cows.

Two operators, eleven cows and six milkings per operator were used to evaluate each system.

Average total time required to milk eleven cows was 51.0, 40.7, and 43.1 minutes for the portable bulk tank, dump station and regular routine, respectively. The longer time for the portable bulk tank was due mainly to more idle man time, idle machine time and time for re-positioning the equipment. The reason for this was that cows were milked in groups of four each and then the tank was repositioned behind four other cows before they could be milked. The disadvantage for the regular routine was in carrying the milk to the milk house. On eleven cows, this operation required a total of 6.60 minutes.

Significant operator differences occurred in the following time elements: Preparation, idle men, stripping and transferring the milking units.

Eight of the fourteen elements showed significant system by operator interactions indicating that different operators reacted differently to the three systems of milking. The interactions consisted of variation in magnitude of the differences between systems from one operator to another. There was no change in rank of the systems among the operators.

The use of the dump station showed the most labor advantage. This advantage would increase with increasing distances from the cows to the milk house. Milk could be transported much farther than the 50 feet indicated in this study. Under conditions of small herd operations, labor might not be as important a factor as the investment in equipment. When this occurs the portable bulk tank might be advantageous. Acceptance or rejection of a system should be based upon the investment in equipment as well as the labor necessary to operate it. (AH g3-10)

3. Bovine Mastitis.

A study was made to determine if there were inherent differences among cows in their resistance or susceptibility to mastitis organisms. Analysis of milk sample data was made from 373 cows in a second lactation and 235 of the same cows during their 3rd lactation. These were data from a 12-year period of sampling milk from all cows during the first 3 months of lactation and taking additional samples whenever strip cup flakes or other mastitis symptoms suggested the possible presence of mastitis organisms.

Eighty-five percent of the cows that showed organisms during the early part of their lactation were clean at the end of lactation. This percentage was the same for cows that were clean during the early part of lactation. However, of the cows that showed organisms periodically throughout their lactation, only 23% were clean at the end of lactation. These results do not show that resistance to organisms is developed when a cow is infected.

The possible repeatability of susceptibility to mastitis infections from one lactation to another was studied from the milk samples obtained from 238 cows in both second and third lactations. Cows were divided into three groups according to the incidence of infections in the second lactation.

In the third lactation, infecting organisms were found in 67.7% of the 99 cows free of infection in a second lactation, 59.2% of the 76 cows infected but later cleared in a second lactation and 68.3% of the 60 cows infected but not cleared when last sampled in a second lactation. These percentages give no indication that susceptibility or resistance to organisms in one lactation indicates what may be expected in the subsequent lactation. (AH g3-8)

4. Antibiotic Detection.

A study was made in cooperation with Eastern Utilization to determine the desirability of using chlorophyl as a marker in detecting the presence of penicillin in milk. Two trials were conducted using four cows with different levels of production (range 13 to 60 pounds of milk per day). Chlorophyl levels of .3, .4, .5, and .6 gms. were mixed with 100,000 units of penicillin in 10 cc carrier and injected into each quarter of each cow. Both penicillin and marker were assayed each milking. The penicillin could be detected at a level of .02 units per ml. of milk up to an average of 6.26 milkings from the time of injection. No differences occurred in penicillin level between trials, marker levels and quarters. Differences were significant between cows with the higher milk level cows ejecting the penicillin before the low level cows.

The presence of the marker was evaluated on a visual basis and with ultraviolet light. An average of 6.51 milkings was required before the marker could not be detected upon visual examination and 7.51 with ultraviolet light. For both methods of detection no differences were found between trials and between marker levels. Differences did occur, however, between cows and between quarters. The lower producing cows and the front quarters retained the marker longer than the high producing cows and the rear quarters.

Correlations were determined for each milking and overall milkings between penicillin and marker levels. At the sixth milking (the approximate time both marker and penicillin had left the udder) the correlations were .73 for visual detection and .64 for ultraviolet detection. The correlations for all the milkings were .81 and .81, respectively. These results indicate that chlorophyl would be quite effective as a marker to detect penicillin in milk.

Another study was conducted using Green 3 and Blue 1 dyes along with chlorophyl. Two gm. doses of the dyes were mixed with .05, .10, .20, and .25 gms. of chlorophyl and 100,000 units of penicillin. These preparations were injected into four different cows, with each quarter receiving a different solution. Two trials were conducted. Penicillin stayed in the udder 6.33 milkings after injection. The chlorophyl could not be detected upon visual examination because of the masking effect of the dyes. However, ultraviolet detection was possible up to 7.35 milkings after injection. The dyes could be detected upon visual observation up to 4.79 milkings after infusion. Significant differences were found between cows, with higher producing cows eliminating the dyes before low producing cows. Rear quarters eliminated the dye faster than front quarters. The green color stayed in the udder longer than the blue color. These results suggest a helpful means for the farmer to keep penicillin out of his milk by visual detection of a dye. They also suggest the use of chlorophyl as a means by which milk plant

operators can detect penicillin and thus prevent its being incorporated into the milk supply. (AH g3-7)

5. Antibodies in Milk.

The purpose of this work is to determine if absorption and/or protection occurs when milk containing antibodies is ingested by humans or livestock. Experiments with calves were designed to duplicate those of Sarwar and Peterson at Minnesota.

Ten calves were used in an attempt to establish a minimum lethal oral dose of the live bacteria (E. Coli #158). The bacteria were given in 50 ml amounts as saline suspensions by use of a tube passed into the esophagus. Doses containing as high as 9.3×10^9 live bacteria per ml were given but none of the calves became sick or died. The highest doses used were approximately four times as large as those used by the Minnesota workers.

Eight calves were used to determine the effect of intravenous injections of the live bacteria. Results showed that 4×10^9 or more live E. Coli #158 would cause death in a few hours. Based on these results the intravenous route was chosen as the method of challenge for the protection experiments. Eighteen one-month-old calves were paired on the basis of age and one of each pair was fed approximately 14 pounds per day for five days of milk containing antibodies against E. Coli #158. This milk was obtained from cows that had been infused with heat killed E. Coli #158 for several weeks prior to freshening. Serological tests on the milk from these cows after they freshened showed the presence of antibodies against E. Coli. The control calf was continued on the regular diet of herd milk. Two of nine calves fed milk with antibodies survived as compared with one of nine control calves.

All calves were bled at birth and tests were made to determine the presence or absence of antibody against E. Coli. None of 23 calves bled before nursing had antibodies against E. Coli #158. Sixteen of 32 calves that received their dam's colostrum had antibodies against E. Coli #158 at one week of age. Titers varied from 4 to 512 at this time. Four of the dams had been infused with the organism to stimulate antibody production and their calves generally had the highest titer. Serological tests were continued at weekly intervals up to four weeks of age and the titer dropped gradually in all cases. Most calves were negative by three weeks and only four of the sixteen originally having antibodies still had a titer at four weeks. Antibodies were not found in the serum of any of the ten, month-old calves fed milk containing them. These results fail to confirm those of the Minnesota workers who reported that antibodies fed in the milk could be detected in the serum and that they could protect calves against challenging doses of live E. Coli #158. Additional work is being done to determine

whether extracts of the antibody milk can protect the calves if given by injection.

In cooperation with the Urology Department of the U. S. Naval Medical Center at Bethesda, antibody milk has been prepared against bacteria isolated from two patients with chronic urinary tract infections. Proteus mirabilis was the organism isolated from one patient and a heat killed suspension of the organism was used for the infusion into two cows. The culture from the other patient contained Proteus mirabilis and E. Coli and the mixture of these two was infused into two cows. The procedure for the infusions was the same as indicated above for E. Coli #158. When the cows calved, milk was sampled, pasteurized and frozen in one quart containers. The antibody titer in the different batches of milk that were processed in this manner ranged from 1:80 to 1:640. However, samples from individual milkings were occasionally much higher. The two patients were put on a twice weekly examination schedule at the hospital. At each visit a blood sample was taken for serological study. Urine was examined for pyuria and the urologist examined the patient. Each patient was given a supply of normal, pasteurized herd milk frozen in one quart containers and instructed to drink a quart a day--a pint at a time. After consuming this milk for two weeks the patients were switched over to antibody milk from the cows that received their respective organisms. The patients did not realize that the first milk did not contain antibodies. One patient drank the antibody milk for one month without detectable effects on his clinical condition or the level of antibody in his serum. The other patient drank antibody milk for six months. There has been no significant change in his condition that could be attributed to the antibody milk. His condition has generally improved but the improvement is considered due to drugs, especially since there was no exacerbation of symptoms during the two months since this patient stopped receiving antibody milk. Serological tests on the serum of both patients indicated the presence of antibodies against the specific organisms involved. The titer varied from time to time but could not be related to the drinking of the milk since the titers did not change at least up to six weeks following cessation of the milk in the one patient studied most extensively.

Another attempt was made to determine if antibodies can be taken orally and pass into the blood in humans. Ten adult males in apparent good health were bled to establish antibody levels, if any, in their blood. Each man drank a quart a day (pint at a time) of antibody milk for seven days and each was bled on the seventh day. Six of these drank milk containing antibodies against Proteus mirabilis and E. Coli. Tests of the before and after blood samples failed to give any evidence whatsoever of uptake of antibodies into the blood. (AH gl-8)

6. Influence of Management Practices and Environmental Factors on Adaptability.

These investigations involve the determination of the effect of environmental influences, including climatic elements, on dairy cattle adaptability and the evaluation of management practices on the performance of dairy cattle in hot and humid regions. This work is cooperative with the States of Georgia, Louisiana, and Texas. Some of the studies are also in cooperation with the Agricultural Engineering and Animal Disease and Parasite Divisions. These projects contribute to the Southern Regional Dairy Cattle Breeding Project, S-49.

Efforts to characterize the response of lactating Jersey cows to a shelter versus no shelter during the summer and winter periods have been conducted for three years at Tifton, Georgia. For the summer, shades constructed of galvanized iron painted white on top were provided both at and away from the feed bunks for the shade group. A similar adjacent area without shade was used for the no shade treatment. In the summers of 1958 and 1959 shade versus no shade for lactating Jersey cows were compared. No difference in milk production was found between the two groups. In 1960 shade was compared to shade plus fans. The fans were used to decrease the humidity caused by the assembling of the animals under the shade. Although the milk production of fan plus shade group was slightly higher than for shade alone, there was not sufficient difference to warrant the additional cost. In 1961 sprinklers were added to shade plus fan lot. The sprinklers were set out separately from the shade over a concrete slab which had been tinted green to reduce surface radiation. The cows had free choice to the sprinkler but did not seem to relish the sprinkler until it was covered. The cows with the sprinkler showed less rise in body temperature, produced slightly more milk (1.5 lb./da./cow) and consumed more dry matter than cows with shade alone. Although not statistically significant, this is the largest difference that has been obtained thus far and may have been more pronounced had the sprinklers been covered for the entire period.

The summer observations of milk production, feed and water consumption and rectal temperature collected over the three-year period (1958-1960) were used to appraise the relative influence of climate on dairy cattle response. The weather measurements and cow responses were separated into 31 independent and 15 dependent variables, respectively. The climatic variables most highly correlated with cow response were average temperature 1100 hr. bulb dry temperature and maximum temperature. The influence of the independent variables, including year and lactation decline, on cow response was estimated by multiple regression. Of the variation observed in milk production and feed consumption, 94 and 40%, respectively, could be attributed to the combined influence of the independent variables. Even so, examination of partial regression coefficients revealed that climate had a greater influence on feed

consumption than on milk production. After correcting animal performance data to a common year for treatment and stage of lactation, only 11 and 23% of the variation in milk production and feed intake, respectively, could be associated with variation in climate. Of the weather variables considered, the single variable having the greatest influence on feed intake and milk production was daily maximum temperature. Simple correlations between a.m. and p.m. cow performance and weather variables indicated that during stressful weather, it is especially important that cows have ample quality feed available both day and night.

In the winter studies, the shelter used during the summer was closed on three sides with plastic sheeting supported on a woven wire frame. The same adjacent lot with no protection was used for the nonshelter treatment. Daily averages of day and night dry bulb and minimum temperatures were 60, 54, and 45° F., respectively, in 1959 and 55, 48, and 38 for 1960. In 1959 the average daily milk yield for the shelter group was 29.6 and 31.5 for the nonsheltered group. Corresponding figures for 1960 were 23.9 and 25.5 pounds per day. Respective average regressions of pounds of milk per cow per day of test for the sheltered and nonsheltered groups were -.060 and -.079 for 1959 and -.078 and -.023 for 1960. The more rapid decline in production of the sheltered cows for 1960 was attributed to differences in dry matter intake. When the body temperatures of the animals dropped due to inclement weather, the nonsheltered cows attempted to compensate through increased feed intake while the sheltered group attempted to prevent a drop in body temperature by remaining under the shelter.

It is recognized that daily climate is best described by using continuous weather observations, but generally this is not practical. In a study of single versus frequent observations for estimating some summer climatic conditions in Southern Georgia, all possible correlations were computed between vapor pressure, dew point, wet bulb temperature and dry bulb temperature at 0800, 1100, 1400, 1700 and also an average of readings at these hours, plus daily solar radiation, hours above 80° F. and maximum temperature. Correlations indicated that wet bulb more satisfactorily measures humidity than dew point or vapor pressure. The correlation of .87 between wet bulb at 1100 and average wet bulb indicated that wet bulb at 1100 is probably the best single measure of humidity for the daytime period. Maximum temperature, solar radiation and hours above 80° F. are related to daytime dry bulb temperature. Of the dry bulb readings, that for 1100 had the highest correlation (.85) with average dry bulb. Correlations of 1100 dry bulb with solar radiation, hours above 80° F. and maximum temperature were .53, .70, and .84, respectively. The best single measure of daily temperature conditions seemed to be 1100 dry bulb. The best two observations for evaluating the daily climate conditions appeared to be dry bulb and wet bulb at 1100 while the best single observation was 1100 or 1400 dry bulb and next was maximum temperature.

Studies of the value of various materials for shade roofing at Louisiana State University have shown that galvanized iron or aluminum painted with white plastic are equally good in reducing solar radiant heat, and superior to polished or nonpolished aluminum, galvanized iron painted with aluminum or plain galvanized iron.

At Louisiana State University, the mean grazing time for Holstein cows during July was 6 hours and 16 minutes per day. The cows did 65% of their total grazing during the day. Mosquitoes became a serious impediment to night grazing. The animals grazed most during the early morning and late afternoon. Among the different climatic components studied, solar radiation appeared to have the most pronounced effect on physiological responses and grazing behavior. This was followed by air temperature, wind velocity and humidity in that order. From this study it appears that lactating cows should be allowed to graze in the early morning and late afternoon with an interim of supplemental feeding. (AH g4-3)

7. Environmental Influences Affecting Production Records.

This project was initiated to develop methods for minimizing the environmental influences on production records and thus improve the records as estimates of genetic merit. The work is carried out at Beltsville, jointly with the Dairy Herd Improvement staff of the Dairy Cattle Research Branch and in cooperation with the Wisconsin Agricultural Experiment Station.

At Wisconsin production and environmental data were collected by 17 DHIA supervisors, project fieldmen and project personnel. Fifty project herds in 5 Southern Wisconsin counties were visited.

Repeatability of various personnel in the evaluation and reporting of environmental data was determined from reports by the three groups of persons. The DHIA supervisors and the project fieldmen were not repeatable with each other in recording herd management ratings which were nonobjectively defined. The project fieldmen and other project personnel were repeatable with each other. With one exception the DHIA supervisors, the project fieldmen and the four other project personnel were repeatable to each other in the evaluation of roughage quality through the use of a descriptive score card. It is likely, as shown by these results, that the pounds of hay and silage and percentage of crude protein on a herd basis and weight by tape on an individual cow basis are reliably reported by DHIA supervisors.

Simple correlations were obtained between herd production and the ratings given by the various personnel to milking practices, housing and cow comfort, disease and injury, housing and care of calves, housing and care of heifers, general farm appearance, condition of

herd and herdsmanship. It was concluded that when the management ratings are considered as a group those reported by the project fieldman and the project personnel were similarly associated with herd production. However, those reported by DHIA supervisors were associated with herd production to a lesser degree. The project personnel did not know the herd level of production at the time of the farm visit.

An effort was made to determine the feasibility of using mark-sense and porto-punch in the recording of DHIA data under field conditions. Five project herds serviced by 5 DHIA supervisors were used for 7 months in the trial.

This study showed that the mark-sense method required less extra time and equipment and could be used more easily and accurately in the field than the porto-punch method. There was no appreciable difference in the two methods at the machine processing center. The existing barn sheet method appeared to be superior in accuracy to either mark-sense or porto-punch method. The major problems in the use of either of the card systems, discounting the possible decrease in accuracy, were training and supervising DHIA field personnel and the vast amount of card shipments to and from the field each month. Estimates of costs with porto-punch or mark-sense methods would be from two-thirds to three-fourths the cost of the present barn sheet method when mailing costs are included. While it appears possible to utilize mark-sensing as a method of recording standard DHIA data and thus reduce the cost of machine processing, it is doubtful if it would be practical under existing conditions of fieldman supervision. The mark-sense method appears to have a real potential in the collection of data by trained personnel such as this project's fieldman.

Studies are in progress to determine the relative accuracy of four laboratory methods of estimating nutritive value of hay through the use of 49 test samples having "in vivo" digestion values. The laboratory methods compared were Morrison's digestion coefficients used in estimating TDN, Pennsylvania State's formula based on crude fiber and crude protein, the Snyder-Lucas regression equation using crude protein, crude fiber and NFE, and an artificial rumen or cellulose digestion procedure. The work was carried out in order to determine which method of estimating nutritive value of hay would be most reliable in testing the hay scorecard.

The correlations between the cellulose digestion values and the "in vivo" digestion values were approximately .71 when estimating TDN or digestible energy. These correlations were considerably higher than those found for any of the other three methods. Therefore, it appears that cellulose digestion as determined by artificial rumen studies provides the best estimate of useful energy in hay and should be used in testing hay scorecards.

A study was made to determine the influence of some environmental and physiological factors on the California mastitis test. This test was conducted once on 1,417 cows with 5,612 milking quarters in 45 co-operating project herds. A total of 60.3% of the cows and 30.6% of the quarters were classified as positive. There was a marked increase in the incidence of inflammation with increasing lactation age. While monthly fluctuations existed, a general increase in percentage of positive quarters occurred during lactation with a low of 18.6% in the 1st month and a high of 39.6% in the tenth month. As daily milk yield declined, the percentage of positive quarters increased from 27.2 to 43.1%. Significant relationships were found between the California mastitis test and man time per cow, line vacuum fluctuations, deviation in pulsation rate, overall sanitation score and yearly butterfat average.

Ease of milking ratings were made on each cow in 45 of the project herds. Each cow was scored very easy, easy, hard, or very hard. The relationship between maximum rate of milk flow and ease of milking, when stage of lactation, lactation number, daily milk yield and age was held constant was 0.355. An estimate for heritability of ease of milking and California mastitis test were computed as .58 and .36, respectively.

A study of 111 management variables and their association with production was made. Those variables having significant relationships with milk yield were: housing and cow comfort, mastitis prevention and control, housing and care of calves, and herdsmanship. The 19 management practice variables which were most highly correlated with herd production accounted for 69% of the variation in milk yield. (AH g5-1)

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DAIRY CATTLE INSECTS
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Problem. Flies, mosquitoes, grubs, lice, and ticks are common pests of dairy cattle that cause important losses in all parts of the United States. The screw-worm, a serious pest of dairy cattle, is prevalent in the southern and southwestern States. Heavy attacks by biting flies lower milk production by 5 to 20%. Total losses to dairy cattle attributable to insects and ticks are estimated to exceed \$200 million annually. Certain insect pests are also involved in the transmission of diseases of dairy cattle. Methods of control for dairy insects have received setbacks during recent years because the best available insecticides and most promising new materials produce residues in milk. In addition, house flies around dairy establishments have developed resistance to DDT and other insecticides. There is, therefore, great need to find safe, effective, nonresidue insecticides and repellents to control these insects and ticks. Effective systemic insecticides and ways of administration which would avoid residues are needed to combat grubs in dairy cattle and to prevent the face fly and horn fly from breeding in the manure. New approaches to control, including radiation and chemosterilants, need to be explored to determine their feasibility for the control of several dairy-cattle pests. Efforts also should be made to find and evaluate insect pathogens, parasites, and predators for controlling certain dairy-cattle pests. Expanded basic studies on the biology and physiology of these pests are needed to find weak links in their life cycle to serve as a basis for the development of more effective and safer methods of control. Research is also urgently needed on the role of insects in the spread of diseases of dairy cattle.

USDA PROGRAM

The Department has a continuing program involving basic and applied research on insects and ticks which affect the health and productivity of dairy cattle. Studies are conducted on the biology, physiology, genetics and nutrition of the screw-worm fly, stable fly, horn fly, horse and deer flies, the face fly, mosquitoes, and other pests; on the nature of insect resistance to insecticides; on the mode of action of insecticides and on their absorption, metabolism and excretion by insects; the effects of irradiation and chemosterilants on insects; insect attractants and repellents; and other new approaches to control. Research is directed towards the development of more effective conventional and systemic insecticides and protective treatments for the control of dairy-cattle pests. Studies are conducted to determine the occurrence of insecticide residues in the tissues and the milk of treated animals. Minor attention is given to the development of sanitation and management procedures and to biological control,

especially parasites and predators, for controlling the face fly, stable fly, horse fly, and several other pests. Studies are conducted in cooperation with the Agricultural Engineering and Animal Husbandry Research Divisions to develop physical and mechanical methods of control, to evaluate traps and devices for estimating and controlling natural insect populations and improved or special equipment for the application of insecticides to dairy cattle. Limited research is conducted on the role of insects and ticks as vectors of animal diseases, with special emphasis on bovine anaplasmosis. The research is conducted in major laboratories at Kerrville, Tex., Corvallis, Oreg., and Orlando, Fla., and at satellite stations at Beltsville, Md., Stoneville, Miss., Lincoln, Nebr., and Fresno, Calif.

The Federal scientific effort devoted to research in this area totals 15.8 professional man-years. Of this number 5.6 is devoted to basic biology, physiology and nutrition; 3.7 to insecticidal and sanitation control; 2.5 to insecticide residue determinations; 0.3 to biological control; 1.9 to insect sterility, attractants and other new approaches to control; 0.3 to evaluation of equipment for insect detection and control; 0.7 to insect vectors of diseases; and 0.8 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 6.7 professional man-years devoted to insect pests of dairy cattle, divided among sub-headings as follows: Basic biology, physiology, and nutrition, 1.0; insecticidal and sanitation control, 3.7; insecticide residues, 1.7; biological control, 0.2; and insect sterility, attractants and other new approaches to control, 0.1.

Industry, especially chemical companies, and other organizations are engaged in research on the formulation and evaluation of insecticides for the control of dairy cattle pests. Industry also cooperates with Federal and State workers in developing information on residues resulting from the use of various insecticides in connection with label registration. Estimated annual expenditures by industry are equivalent to approximately 10 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Basic Biology, Physiology, and Nutrition

1. House Fly. Studies in Oregon showed that DDT-resistance in house flies was attributable to the ability of the flies to dehydrochlorinate the insecticide. The mechanism of resistance in house flies to the carbamates was due to alisterase activity, the same as for the organophosphates.

Studies in Oregon showed that P^{32} metepa was rapidly absorbed and metabolized by house flies and mice. Almost complete degradation occurred in 24 hours with phosphoric acid being the major metabolic product.

Studies in Oregon indicated that irradiation of resistant flies with 1000 r did not alter their susceptibility to insecticides or esterase activity. Irradiated females mated with normal males produced normal numbers of eggs but only 45% were fertile.

Further studies were conducted with normal and parathion-resistant flies that had been irradiated as pupae with 600 r for 7 generations. Only about 25% of the eggs hatched from matings of irradiated males and females of either colony. No changes in either esterase activity or insecticide susceptibility were apparent.

In Oregon studies showed that certain synergists greatly increased the toxicity of malathion to resistant strains of house flies. The synergists, simple tris-substituted derivatives of phosphoric acid, completely overcame high levels of resistance when used at 1:1 or higher ratios of synergist to insecticide. The most effective materials increased the toxicity of malathion from 36-to-40-fold against resistant house flies. Only about a 2-fold increase was indicated against susceptible strains of house flies. The relative ability of several of these materials to synergize malathion against resistant house flies was directly related to the inhibitory effect of the synergists on aliesterase activity. Strong synergists for malathion inhibited aliesterase activity at concentrations as low as 10^{-5} M, while related nonsynergistic materials failed to inhibit the aliesterase at concentrations up to 10^{-2} M. The synergists may actually inhibit the mutant aliesterase present in all organophosphate-resistant fly strains.

House flies treated with the synergist tributyl phosphorothioate and then treated with either parathion or paraoxon accumulated greater quantities of paraoxon than did flies treated with the toxicants only. This was true with both susceptible and parathion-resistant strains of flies. Measurements of the inhibition of thoracic cholinesterase activity provided a far better picture of the toxic action of organophosphates than did measurements of head cholinesterase.

In Oregon selection of a house fly colony with Isolan produced a strain with 3-fold resistance in 14 generations. At the same time, levels of esterase activity to methyl butyrate declined to 40% of the original level in flies of the selected strain. This same phenomenon occurs when house flies are selected with organophosphates, indicating that the same mechanism is responsible for resistance to both classes of insecticides.

House flies were capable of dispersing a distance of at least 5 miles in 24-48 hours. In one series of tests, males sterilized by feeding 3 days on apholate proved fully competitive with normal males when placed with normal females. When only treated males were placed with fed females all eggs were sterile and 12.5% were sterile when only normal males were present. When fed females, normal males, and treated males were combined at ratios of 1:1:1 and 1:1:2, 65 and 80% of the eggs were sterile and higher ratios of 1:1:3, 1:1:5, and 1:1:10 resulted in 99.9-100% sterility. Additional tests at these ratios confirmed that actual sterility was higher than the expected.

In Florida cytological studies showed that the ovaries in normal 3-day-old flies were 6-8 times as large as those in females fed for 3 days on 1.0% apholate. After feeding ceased some growth occurred but ovaries never attained normal size. Females mated to males fed on 0.4-1.0% apholate oviposited but the eggs showed little or no embryonic development, whereas females mated with males fed 0.1-0.3% laid some viable eggs and some without embryonic development. Similar results were obtained in tests with normal and insecticide resistant strains of flies.

In further studies on the cytological effects 1% apholate given in adult food over a period of 24 hours inhibited but did not eliminate ovarian development in females. The greatest effect was noted at 72 hours after eclosion of the nurse cells in the first and second egg chambers. The chromatin was irregular and nuclei had bizarre shapes. Oocytes matured in the first cell but not in the others. The germarium was also affected as the third egg chamber was not visible until 168-192 hours after eclosion compared to 96 hours in normal flies.

2. Mosquitoes. Studies were initiated at Fresno, Calif. in July, 1961, on the biology of mosquitoes in relation to agriculture, especially with regard to irrigation and land management practices, in cooperation with the Soil and Water Conservation Research Division and the Bureau of Vector Control of the California State Department of Health. Early studies showed that dairy drains are sites of heavy breeding of Culex quinquefasciatus through November and into early December. The breeding in such locations contributes heavily to overwintering adult population of this species. No autogeny (ability to lay eggs without a prior blood meal) was observed in this vicinity with Aedes vexans, Culex apicalis, C. peus, and C. thriambus.

In Oregon studies on flight movements of tarsalis indicated that they move from their resting stations about sunset and return about sunrise. The instinct of tarsalis to oviposit in low sites is stronger than the instinct for oviposition in favorable waters. Female tarsalis mate only once, whereas males mate several times.

Studies were continued in Oregon on insecticide resistance in mosquitoes. Tests showed that DDT-resistant Culex tarsalis larvae breeding on farms and in log ponds were also resistant to closely related compounds, but not to dieldrin or lindane. Further spread of resistance in Oregon Culex mosquitoes was indicated when Culex peus showed some apparent resistance to DDT, and tarsalis, for the first time in the State, showed some resistance to malathion. Studies on the physiology of resistance showed that malathion-resistant larvae of C. tarsalis were more efficient in regulating salt (chloride) uptake than susceptible larvae during exposure to malathion. Resistant and susceptible larvae took up similar amounts of chloride when exposed to 1% sodium chloride alone. Exposure to 1% sodium chloride resulted in an increase in oxygen consumption in susceptible and malathion-resistant larvae, but chloride had no measurable effect on cholinesterase inhibition or accumulation of malaixon, the principal breakdown product of malathion in mosquitoes. Studies of the insect enzyme systems, cholinesterases and aliesterases, led to the development of synergists for organophosphorus insecticides. Several tris-substituted derivatives of phosphoric acid overcame the resistance of tarsalis larvae to malathion, increasing its toxicity 100-fold to a resistant strain. Only about a 2-fold increase was indicated against normal strains. The ability of the synergists to overcome resistance appears to be related to an increase in the titer of a carboxyesterase enzyme. In general, the accumulation of malaixon was proportionate to the effectiveness of the synergist. Malathion-resistant tarsalis detoxify DDT 2-to-3-times as fast as normal strains, largely through the formation of carboxylic derivatives. The DDT detoxifying enzyme, DDT-dehydrochlorinase, in flies does not occur in tarsalis.

Studies in Florida showed that metepa was picked up rapidly by tarsal contact from glass surfaces by both mosquitoes and house flies. House flies and A. quadrimaculatus absorbed approximately the same amount (7 ug./insect) during a 4-hour exposure on surfaces treated at 10 mg./sq. foot. The quadrimaculatus males were so damaged that they could not inseminate the females but house fly males were normal in this respect and 99% of the eggs produced from matings with virgin untreated females were nonviable. Aedes aegypti showed an average uptake of 2.5 ug./insect, which sterilized but apparently did not impair male activity. Feeding for 3 days on treated food (1% of the chemical in 20% honey solution with mosquitoes, and 0.4% in house fly food) sterilized quadrimaculatus males and caused a high degree of sterility in house fly and aegypti males. At the end of the 3-day feeding period the amount of tagged material, expressed at ug.-equivalents of P^{32} metepa was 3.0, 3.7, and 1.7 in males of quadrimaculatus, house flies, and aegypti, respectively. Exposure of larvae from the third instar through pupation in water treated at 10 p.p.m. failed to sterilize quadrimaculatus or aegypti significantly and the uptake of metepa was low in comparison to the other types of treatments.

Studies in Oregon showed that P^{32} metepa was rapidly absorbed and metabolized by mosquitoes (C. tarsalis) and mice. Almost complete degradation occurred in 24 hours with phosphoric acid being the major metabolic product.

3. Stable Fly. Studies were continued in Nebraska on the biology of stable flies. Immature stages of the stable fly overwintered in protected situations. None survived in environments subject to frequent freezing and thawing. The first adult flies appeared on June 1 and gradually increased through June. Peak populations occurred during July and August.

Efforts were continued in Nebraska to induce resistance to DDT in stable flies. After selection with topical applications of 0.005-0.075% DDT for 3 $\frac{1}{4}$ generations, no resistance was apparent and the colony was discontinued. However, when 36 p.p.m. of DDT was placed in the larval medium, 3-fold resistance was indicated in 6 generations. After 11 generations (1 year), the colony tolerated 500 p.p.m. on the media and some larvae survived 625 p.p.m. Resistance of about 14-fold was indicated.

4. Face Fly. In Nebraska, adults of the face fly hibernating in homes became active in February. Collected females contained well developed eggs but did not oviposit in the laboratory. Adults were first observed on cattle at Lincoln on May 14 and by late June, herds were lightly infested. High populations persisted from early July until cool weather.

After considerable investigation of nutritional requirements, a thriving colony of the face fly was developed under laboratory conditions. The adult diet consisted of cattle feces, citrated blood, milk, dimalt and bee pollen. Larvae were reared in cattle feces and pupated in a mixture of sand and vermiculite. The life cycle (egg to egg) was 14 days at 82° F. and 28 days at 70°.

5. Horn Fly. Studies on the biology of the horn fly were continued in Texas and Oregon. In Texas intensive spraying was employed to eradicate horn flies at one location during the late fall, whereas flies persisted in other locations until early December. In the spring flies reappeared at untreated locations nearly 4 weeks earlier than at the treated location. The flies overwintered as diapausing pupae and prepupae. In Oregon horn flies overwintered as pupae in cattle droppings but house flies and stable flies failed to survive. Adult horn flies began emerging from overwintering pupae on May 17 and emergence was complete by June 24. Emergence ranged from 0.8 to 14.8% in exposed droppings and from 3 to 61% in those protected by screen cages.

In laboratory studies in Oregon occasional eggs of the horn fly hatched at a constant temperature of 52° F. and the larvae developed to pupae but no adults emerged from them. Adults also failed to emerge from 1-day old pupae reared at 80° and then kept at a constant temperature of 52° for 3 months but, when returned to 80°, 20% produced adults in 5 days. When 5-day old pupae were transferred from 80° F. to 52° adult emergence occurred between 7 and 23 days, whereas at 80° it was complete in 1 to 3 days.

In Texas a laboratory colony of the horn fly has been developed and maintained for 10 generations without contact with a bovine host. The adult diet consists of bovine blood, ground beef juice and an antibiotic to prevent spoilage. The optimum temperature for survival and reproduction is 90° F. Larvae are reared in feces of cattle fed alfalfa hay. The feces of cattle fed sorghum or prairie grass proved unsatisfactory as larval media.

6. Screw-worm. Investigations on the screw-worm were conducted at Kerrville, Tex. The sexual development and behavior and genetics of the screw-worm fly were studied. Dissections showed that egg development was synchronous in all ovarioles. The exact stage of development of the oocyte and the nurse cells and the cytological condition of the nucleus were determined for various ages of females. Males began mating when 2-days old but were not vigorous in mating until 4 days of age.

The number of adults in holding cages and mating activity had pronounced effects on longevity. Optimum longevity occurred when not over 100 adults were confined in 12" x 12" x 20" cages. Adults also lived longer when the sexes were kept separate and when the male to female ratio was reduced. Excess mating by males and harassment of females by males reduced longevity.

Efforts were made to develop a genetically distinct strain of screw-worm fly. In examining many thousands of adults from scores of strains a black mutant male was discovered. Selected matings resulted in the development of a homozygous black strain. When this strain proved inferior to normal strains in longevity and mating vigor, new genes were introduced by mating black females to normal blue males. After inbreeding for several generations, the black strain was equal to normal strains in longevity and mating vigor. Several additional new strains have been developed from larvae and adults, including one in which the scutellum is fused laterally to the scutum. Linkage studies with "black" and "interrupted" marker strains showed that these genes are sex linked on the "X" chromosome. Crosses of these strains did not produce the expected number of black males, and females homozygous for the "interrupted" gene did not survive as well as the heterozygotes.

Efforts to formulate a completely synthetic larval rearing medium have proved unsuccessful so far, but progress has been made in developing

a modification of the standard ground meat-blood medium. Screw-worm larvae reared for 48 hours on the standard medium consisting of 50% horse meat, 30% bovine plasma and 20% water were successfully transferred and completed development in media in which 50, 75, 87.5, and 100% of the horse meat had been replaced with fish flour. The substitution of the fish flour reduced production costs to as low as 8.7¢ per thousand pupae, compared with 21.4¢ for the standard medium. Weights of the larvae ranged from 73.0 to 69.6 mg. for the 50 to 87.5% substitutions, as compared with 74.6 mg. for the standard. The 100% substitutions yielded larvae that weighed only 60.2 mg., but the adults lived slightly longer than those produced on the standard medium. In cage tests the small males and normal-sized males mated about equally as well with normal-sized females.

Intensive studies were made on the effects of irradiation on the sexual development, mating ability and longevity of the screw-worm. A dosage of 5,000 r completely sterilized both sexes. No oviposition resulted from matings of irradiated males and females and normal males and irradiated females, whereas matings of irradiated males and normal females resulted in normal oviposition but none of the eggs hatched. Female flies 0-4 hours old were more sensitive to irradiation than 5-day old pupae. A dosage of 2,000 r reduced ovarian growth by 50% in young females but had no significant effect on ovarian growth in females irradiated as 5-day old pupae. Irradiation had little or no effect on ovarian growth in females over 48 hours old. However, oocytes in 4 to 5-day old females were damaged more by irradiation than those in 3-day old flies. No difference was noted in the longevity of 5-, 6-, and 7-day old flies irradiated with 7,500 r in one, two, or three exposures. The number of dominant lethals and longevity of adults were unchanged regardless of whether 5-day old pupae were irradiated with a single dose or equal fractions at intervals of 8 and 2^{1/4} hours.

There was no consistent difference in the effects of 1,000 and 5,000 r administered as a single dose or two equal doses. Female flies 3-, 4-, and 5-days old differed greatly in radiation sensitivity but dominant lethals were induced in the oocytes of all ages. In additional tests with 5-day old pupae, which have only oogonial cells, the number of eggs deposited by females decreased as the radiation dose increased, indicating that damage to some cells eliminated them from the germ line and that they were not rapidly replaced.

Additional studies on the effects of irradiation on 4-, 5-, 6-, and 7-day old screw-worm pupae showed decreased longevity of adults with increased dosage. All stages showed lower mortality at 2800 r than at higher dosages.

When female screw-worms were irradiated as 5-day old pupae in a well-aerated container, a dose of 5000 r produced 99% sterility. When the

same dose was given in an atmosphere of carbon dioxide less than 50% sterility resulted. However, irradiation in an atmosphere of 50% air and 50% CO₂ produced a greater effect than in air alone. These results suggest that the irradiation capacity of the present Cobalt-60 sources could be increased by 38% by irradiating with 5000 r in 50% air-50% CO₂. For this synergistic effect to be shown, it is necessary that the insects be held in the CO₂-air mixture for at least 30 minutes prior to, as well as during irradiation. It should be a relatively simple engineering job to modify the currently used procedures for such irradiation.

Studies were conducted on the absorption, distribution, metabolism, and excretion of P³² metepa (chemosterilant). Metepa was absorbed faster and excreted more slowly by the stable fly than the screw-worm fly. This may account for the fact that the sterilizing dose of metepa is much less for the stable fly than for the screw-worm fly.

Field cage studies in Texas showed that mature screw-worm larvae released on soil at 73° F. entered the ground in 3-4 minutes and pupated in 24 hours. Peak emergence of adults occurred 12 days later between 5:00 and 8:00 a.m. Adults did not feed or exhibit mating activity until 4 days old. Adult survival was high for 9 days, but very few adults were alive after 22 days. In similar releases when soil temperatures were 51° F. few larvae entered the soil and although many were alive after 1 week, none had pupated.

Work was conducted on the dispersal and behavior of marked released adult screw-worm flies. The first night after release from 0.4 to 10% of the marked flies were recovered within 25 yards of the release point. Recoveries decreased on successive nights. In some tests none apparently moved over 400 yards, whereas in others, dispersion was rapid, as far as 1 mile in 45 minutes. Over 90% of the adults were found resting near the tips of leafless twigs within 4-5 feet of the ground.

7. Cattle Grubs. Research was initiated in Texas and Oregon to determine the nutritional requirements of cattle grub larvae and to develop an artificial medium for rearing larvae under laboratory conditions. Second and third stage larvae have been successfully reared to maturity in serum in shell vials, but adult emergence from the pupae was quite low. Efforts to develop a suitable medium and techniques for rearing first stage larvae have proved unsuccessful so far.

8. Horse Flies and Deer Flies. Studies were continued in Mississippi on the biology of tabanids. The earliest species, Tabanus lasiophthalmus, appeared on March 31, reached a peak by late April, and disappeared by late May. T. vittiger schwartzi, the most prevalent species, appeared April 5, was abundant from mid-May until

early July and small numbers persisted until cool weather. *T. fuscicostatus* appeared May 11, reached a peak in June and disappeared by early September. Other species of lesser importance and dates of their occurrence were as follows: *T. proximus*, June 8 to September 7; *T. lineola*, April 26 to October 5; *T. americanus*, May 24 to August 17; and *Chrysops flavidus*, May 11 to October 19. Eighteen species were collected during the season. Several species of adult flies were successfully collected and fed in confinement on cattle. Females of *T. proximus* and *T. vittiger schwardti* produced egg masses in captivity and the eggs hatched in 7 and 4 days, respectively.

9. Lice. Studies were conducted in Oregon to determine the factors involved in the decrease of cattle louse infestations during the spring and summer and the increase of populations during the fall and winter. The free cattle harbored very few lice after shedding their winter coat in the spring, but when they were restrained heavy infestations developed within a month. When released the cattle licked and rubbed themselves constantly for several days, causing a precipitous decline in louse populations. During the winter the heavy coats on the animals apparently minimized the effects of rubbing and licking and as a result high louse populations persisted throughout the winter.

10. Ticks. Work in Texas indicated that irradiation at the rate of 1000 r had no effect on the molting of unfed or engorged nymphal lone star ticks. However, a dose of 2500 r prevented molting of unfed and 1-day engorged ticks and only 3% of those engorged 1 week molted to adults. Exposure of newly molted nymphs to 1000 r completely sterilized the males but not the females.

B. Insecticidal and Sanitation Control

1. House Fly. Investigations on these insects were conducted at Orlando, Fla. One hundred ninety-five new compounds were screened for residual effectiveness against house flies. Twenty-four materials were 90-100% effective for at least 24 weeks as compared with 12-16 weeks for malathion (standard). These materials included Thiodan, General Chemical GC-3583, Shell SD-4402, Upjohn TUC U-12927 (with synergist); Bayer compounds 29952, 30237, 30468 and 29492; Hooker HRS-1422, Geigy G-27365, Stauffer N-2404, heptachlor epoxide and twelve confidential compounds. Bayer 29952, Bayer 30237 and seven of the confidential compounds were still 100% effective after 44-48 weeks and are considered unusually promising for controlling flies. Several promising new compounds were evaluated as space sprays against susceptible and resistant strains of house flies. Some of the compounds were superior to malathion (standard) against susceptible flies but only one, Bayer 30911, was superior against resistant strains.

Over 50 selected compounds were evaluated as bait toxicants against resistant and normal strains of house flies. Eight of the compounds were equal or superior to Dipterex (standard) against both strains of flies, namely, Bayer 30237, Bayer 30554, General Chemical 6506, Stauffer N-2230, Stauffer N-2404, dimethoate and two confidential compounds. All of the compounds tested were more effective against normal than against resistant flies.

Several materials which increased the effectiveness of malathion in laboratory tests were evaluated as residual treatments in barns against large populations of flies. Combinations of several synergists and malathion alone were equally ineffective in these tests.

2. Mosquitoes. Studies were continued in Florida to find more effective residual insecticides for controlling mosquitoes. Of over 500 new compounds screened for toxicity to Anopheles quadrimaculatus larvae, five were outstanding in their effectiveness. Of 157 selected compounds screened against female adults of Anopheles quadrimaculatus, 17 were very promising causing 90 to 100% kill of exposed quadrimaculatus for 24 weeks. Four of the compounds, Bayer 39007, Hercules 7522C, Bayer 34098, and Bayer 4183, retained their effectiveness on sprayed surfaces for 1 year. In tests with treatments that had aged for 2 years, Sevin and Hercules AC-5727 plus piperonyl butoxide caused 85% kills of quadrimaculatus within 24 hours after a 1-hour exposure to 100 mg./sq. ft., whereas malathion and unsynergized AC-5727 were ineffective.

In Florida, tests in the laboratory and field were continued to develop more effective materials for mosquito control. Of 151 selected compounds tested as space sprays against colonized Aedes taeniorhynchus, four were better than the malathion standard: Kenya Oleo Resin, Bayer 34042, Bayer 30749 and Hercules 7522C. In aerial spray tests against natural populations of salt-marsh mosquito adults, 0.05 pound per acre of Dibrom or DDVP was about as effective as 0.1 pound of malathion per acre. The sprays reduced mosquito abundance more than 90% in 6 hours.

In Oregon screening tests were conducted with a number of new insecticides against larvae and adults of Culex tarsalis. Three of the materials gave 100% kills of larvae at a concentration of only 0.025 p.p.m. In spray tests seven materials were 2 to 9 times more toxic to adult mosquitoes than malathion (standard) and one, Bayer 39007, compared favorably with parathion.

In Oregon studies were continued to find repellants for protecting animals from mosquitoes. None of 200 compounds screened in spot tests on cattle showed promise.

3. Stable Fly. In Texas, where the research on the stable fly was done, 447 compounds were screened in spot tests on cattle for repellency and toxicity against the stable fly. Of these materials 9 were Class IV repellents at 5%, 8 were Class IV repellents at 10% and 3 were Class IV toxicants at 0.5% and 2 were Class IV toxicants at 5%. The outstanding repellents were diamyl tartrate, 3-ethyl-2,4-octanediol, benzyl acetoacetate, piperonyl chrysanthemumate and Hercules AC-6432. Three other materials were slightly less effective. The most effective toxicants were Geigy G-27365 and Shell SD-2359.

Comparisons were made of the toxicities of various insecticides to stable flies. The LD-50's in ug/fly for the materials tested were as follows: Ronnel, 0.015; methoxychlor, 0.057; DDT, 0.072; DDT and WARF, 0.091; toxaphene, 0.17; Diazinon 0.021; pyrethrins, 0.021-0.028; and pyrethrins and piperonyl butoxide, 0.017.

Large cage tests were conducted on calves to compare the residual effectiveness of a number of new insecticides and methoxychlor (standard). Ruelene, Baytex, Bayer 22408 and Sevin were effective for 3 to 5 days against stable flies but were less effective than methoxychlor.

Extensive tests with pyrethrum showed that ultra-violet light was the most important factor in its rapid loss of effectiveness, although infrared was also deleterious. Wave lengths in the range of 2600-4000A caused the greatest loss in effectiveness of pyrethrum. Several hydroquinone antioxidants and lanolin prolonged the toxicity of pyrethrum about two-fold under irradiation. Several phosphoric acid derivatives increased the effectiveness of malathion against stable flies but had no effect on Sevin or methoxychlor.

Of 111 compounds tested as systemics, only 8 caused mortality of stable flies feeding on guinea pigs. Hercules 7522-H and Rhodia RP-9895 were effective orally at 50 and 100 mg./kg. The other six materials were effective orally at doses of 10 to 50 mg./kg. but their chemical names are confidential. Thirty Class IV repellents were administered orally to guinea pigs to determine if they would prevent feeding by stable flies. All were ineffective.

4. Face Fly. In Nebraska a number of insecticides were administered to cattle in feed in order to determine levels necessary to prevent fly breeding in the feces. Daily doses of V-C 13 at 4 mg./kg., Cygont at 5 mg./kg. and Co-ral at 10 mg./kg. gave 100% control of breeding but seven other materials were only partially effective at the doses tested. Sprays of methoxychlor, malathion, Delnav and synergized pyrethrins provided little or no control of this pest. Halters treated with DDVP, Dipterex and methoxychlor reduced fly populations but did not provide satisfactory control. Effective control of breeding was obtained by feeding Co-ral at 0.5 mg./kg. and ronnel at 7.8 mg./kg. daily but adult populations on the cattle remained high, presumably because of migration

from adjacent farms. Weekly applications of 0.08 lb./acre of Co-ral on pastures prevented fly breeding in droppings of cattle but here again no effect on adult populations was apparent.

5. Horn Fly. In Texas tests were conducted on calves in large cages to compare the residual effectiveness of a number of new insecticides and methoxychlor (standard) Ruelene, Baytex, Bayer 22408, and Sevin were effective for 7-10 days as compared with 17 days for methoxychlor. Extensive field tests were conducted in Texas and Mississippi to compare several old and promising new insecticides for the control of horn flies on cattle. In Texas effective control was obtained with 0.25% sprays of GC-4072 for 15-21 days, with 0.06% Diazinon for 8-12 days, and with 0.5% Dilan, Dipterex and methoxychlor for about 2 weeks. In Mississippi control was obtained for 11-14 days with 0.1-0.25% sprays of ENT-27717, for 7-10 days with 0.25% Sevin, and 0.1% Baytex, for 3 weeks with 0.5% Dilan and methoxychlor, for 10-30 days with 0.25-0.5% Shell 4294. In season-long tests, effective control of horn flies was maintained with 4-5 sprayings with 0.25% Shell 4294, with seven sprayings with 0.1%, and with two applications of 2% in oil to backrubbers. Effective control was also maintained with mist sprays of 1% Shell 4294 applied weekly and of 0.05% pyrethrins and 0.01% DDVP applied daily.

Extensive tests were conducted to determine the effectiveness of low level feeding of insecticides in controlling horn flies. In Texas daily dosages of 7.8 mg./kg. of ronnel prevented horn fly breeding in droppings and reduced adult populations to a sub-annoying level within a week. Free choice feeding by cattle on ronnel salt blocks also provided very good control. Other effective materials and dosages were as follows: Co-ral, 0.5 mg./kg.; Bayer 22408, 1 mg.; GC-4072, Baytex, Bayer-34727 and Stauffer R-1504, 2.5 mg./kg.; and Bayer 37342, American Cyanamid 38023 and Bayer 37341, 10 mg./kg. In Mississippi free-choice feeding on ronnel salt blocks and daily feeding at 4 mg./kg. prevented breeding in droppings and adult fly populations decreased significantly.

6. Screw-worm. In Texas research was continued to develop more effective insecticides for controlling screw-worms affecting livestock. One hundred thirty-one new compounds were screened for systemic action by administering them orally and subcutaneously (SC) at several dosages to guinea pigs artificially infested with screw-worms. Ten of the materials showed systemic action in one or both types of administration. The active compounds and minimum effective dosages in mg./kg. were as follows: Stauffer N-2310, Stauffer N-2599 and Stauffer N-3055, 25 mg. orally and 50 mg. SC; Stauffer N-3054, 10 mg. orally and 50 mg. SC; Hercules 9699, 50 mg. orally and SC; Stauffer R-3422, 50 mg. orally and 100 mg. SC; Rhodia 9895, 50 mg. orally and Hercules 7522H, 100 mg. orally.

Screw-worm larvae surviving the screening tests of new compounds were collected and reared to adults. The adults were mated and records made of the number of eggs and percent hatch to determine if the chemicals screened produced any sterilizing effects. Of 121 compounds used in this study 13 adversely affected survival and development of larvae and pupae or oviposition and egg hatch. The most active materials and their effects were as follows: Bayer 38636 at 5 mg. orally, all male survivors; Shell 7079 at 50 mg. orally, no oviposition; Stauffer R-2404 at 10 mg. orally and SC, no hatch; ENT 573⁴ at 100 mg. SC, adults emerged but died without ovipositing; and Dilan at 500 mg. orally, no adult emergence from pupae.

7. Cattle Grubs and Other Bots. Research was continued in Texas, Oregon, and Nebraska to develop more effective insecticides for controlling cattle grubs and other bots affecting livestock. The ten out of the 131 materials screened in research on the screw-worm in Texas showed systemic action and are promising for further work in the control of cattle grubs.

In Texas further tests were conducted on small numbers of cattle with a number of compounds that had shown promise in screening tests or on individual cattle in 1960 and 1961 and with older effective materials administered in different ways. Ten of the new materials gave 98-100% control of grubs by one or more routes of administration. These materials, the effective doses, and routes of administration were as follows: Famophos, 25 mg./kg. intramuscularly (IM) and 10 mg./kg. in feed for 10 days; Bayer 373⁴1, 0.5% spray, 2% pour-on, 10 mg./kg. orally, and 5 mg./kg. in feed for 10 days; Bayer 34727, 0.5% spray and 25 mg./kg. orally; Stauffer 3352, 25 mg./kg. orally; Stauffer 3828, 100 mg./kg. orally; Stauffer R-1504, 0.5% spray, 2% pour-on, 50 mg./kg. orally and 25 mg./kg. in feed for 10 days; Bayer 373⁴2, 0.5% spray, 25 mg./kg. orally, 15 mg./kg. IM, 5 mg./kg. in feed for 10 days and 10 mg./kg. in feed for 6 days; Bayer 37289, 25 mg./kg. orally; Bayer 42600, 25 mg./kg. orally; and Rhodia, 100 mg./kg. orally.

The older materials, dosages and routes of administration giving 98-100% control of grubs were as follows: Co-ral, 2% and 8% pour-on; Dipterex, 5 mg./kg. in feed for 10 days, 6% pour-on and 150 mg. orally; Baytex, 2.5 mg./kg. in feed for 10 days and 10 mg. IM; Butonate, 5 mg. in feed for 5 days and 10 mg. in feed for 10 days; and Ruelene, 10 mg. IM and SC. In additional tests with GC 4072 one and two sprays of 0.25% gave 94% control. Several other materials were 78-91% effective by one or more methods of administration.

Extensive field tests with government and cooperator herds of cattle were conducted in Texas, Oregon and Nebraska to evaluate the effectiveness of promising new and several older systemics at different rates and various methods of administration. In Texas 99-100% control of grubs was obtained with Co-ral at 5 mg./kg. IM and as a 4% oil solution applied to the backline by the pour-on method. Pour-on

applications of 4% in oil and 2% in oil and water and 0.5% sprays were over 90% effective. Dipterex applied as a 1.5% spray and at 4% and 7.75% pour-on treatments gave 99-100% control of grubs. Ten percent pour-on applications of ronnel were 99% effective. Ruelene gave 95-100% control when applied at 2%, 4% and 7.75% by the pour-on method and as a 0.5% spray or dip. Baytex as a 1% pour-on and as a 0.25% spray gave 96 and 98% control. New materials giving 94 to 99% control were Bayer 37342 as a 0.5% spray and Famophos at 15 mg./kg. IM. Some of the older and newer materials failed to provide satisfactory control at lower dosages or by other methods of administration.

In Texas tests involving a number of cooperator herds were conducted to evaluate ronnel in salt blocks and as a feed supplement for the control of grubs. Feeding ronnel at the rate of 7.8 mg. daily for 14 days failed to give satisfactory control. Consumption of 2.6-2.8 mg./kg. daily of ronnel from the salt blocks for 4 months gave 78 to 86% control of grubs. Excellent control of 97% was indicated in herds given 7.8 mg./kg. of ronnel for 14 days and then provided with ronnel salt blocks for 3 months.

In Nebraska field tests were run to evaluate the effectiveness of Famophos as an intramuscular (IM) injection against cattle grubs. Injections of 15 mg./kg. gave 99% control as compared with 90% for 7.5 mg./kg.

In tests in Oregon with older materials 98 to 100% control of grubs was obtained with the following treatments: Ruelene as 0.25 and 0.5% sprays; Dipterex as 1% and 2% sprays; Co-ral as a 0.5% spray; Baytex as a 0.25% spray, and a 25 mg./kg. in oil pour-on treatment, and in 5-day feeding tests at 5 mg./kg. Baytex also gave good but variable control at lower rates as sprays and pour-on treatments. In tests against grubs already present in the backs of cattle, 85-100% kill was obtained with pour-on treatments of Baytex at 25 mg./kg. and with 2.5% dusts of DDVP and Dibrom. In tests with new materials excellent control was obtained with Bayer 37342 as a 0.25% spray and orally at 50 mg./kg. and with Famophos as a pour-on at 15 mg./kg. and in feed at 10 mg./kg. for 5 days. Bayer 37341 was highly effective as a 0.25% spray in some tests but not in others. Lower dosages of these materials and all dosages of several other new materials failed to give satisfactory control of grubs. Feeding of ronnel at the rate of 7.8 mg./kg. daily for 14 days resulted in reductions of 94 to 98% in grubs in several groups of cattle.

In Oregon topical application tests showed that male H. bovis adults were more tolerant of ronnel than females. The LD-100's were 180 and 100 ug/fly, respectively.

8. Horse Flies and Deer Flies. In Mississippi studies showed that daily applications of synergized pyrethrins with an automatic sprayer

greatly reduced the number of horse flies and deer flies attacking cattle. Sprays of insecticides, such as toxaphene, malathion and Ciodrin, were ineffective in repelling biting flies but a good percentage of those that engorged died subsequently from contact with the insecticide.

9. Lice. In Mississippi 25 promising new insecticides were evaluated in spot tests in comparison with methoxychlor against cattle lice. Two materials - General Chemical and Bayer 37342 - prevented re-infestation for 12 days as compared with 7 days for methoxychlor. Heavy infestations of horse lice were eradicated with 0.5% malathion sprays. Nine materials were evaluated for systemic action by giving them orally to louse-infested cattle. Co-ral caused 100% kill of all motile lice but the other materials were partially or completely ineffective at the dosages tested.

In Texas extensive field tests were run to compare the effectiveness of several of the newer insecticides against cattle lice. Sprays of 0.25% GC-4072 eradicated lice in a majority of tests but in others, light infestations developed within 2-4 weeks. Ronnel and Shell 4294 at 0.25% gave 100% immediate control but light reinfestations were apparent in all locations in 2-4 weeks. Ruelene applied at the rate of 75 mg./kg. along the "back line" eliminated louse infestations but lower dosages of 25 and 50 mg./kg. were not completely effective. Feeding of 50-75 mg./kg. of Ruelene over a period of 3 days reduced louse infestations only 40-50%. Daily feeding of Co-ral at 0.25 mg./kg. and Bayer 22408 at 0.5 mg./kg. for 3 weeks or more had no noticeable effect on louse infestations.

In Oregon complete control of cattle lice was obtained with sprays of 0.5% Co-ral, 0.25% Baytex and 0.75% lindane. These treatments gave complete control of cattle scabies, (Chorioptes bovis).

10. Ticks. Work on ticks was confined to the Texas laboratory. Only 4 of 131 compounds screened for systemic effectiveness showed systemic action against ticks engorging on treated guinea pigs. The effective materials, dosages (mg./kg.) and routes of administration were as follows: Rhodia, 25 mg. orally and 50 SC; Hercules 9699, 50 mg. O and SC; Stauffer N-2310, 50 SC; and Zectran, 50 mg. orally.

Evaluation was made of the effectiveness of 71 insecticides against Boophilus ticks, using the dipping technique. A majority of the materials were toxic to this species, but the most effective were lindane, Co-ral, General Chemical 3582, General Chemical 4072, Bayer 25141, Bayer 29952, Bayer 30237, and Bayer 37341.

Extensive field tests were conducted to compare the effectiveness of several insecticides against the winter, lone star, and black-legged ticks on cattle. Complete control of existing infestations of the

winter and black-legged tick was obtained with sprays of 0.1% General Chemical 3582, 0.25% Shell SD-4294 and General Chemical 4072, 0.5% methyl Baytex and toxaphene. Dilan at 0.5% and V-C 13 at 0.25% eliminated the black-legged but not the winter tick. Sprays of 0.05% Diazinon and 0.5% V-C 13 gave lower immediate kills of the winter tick than 0.5% toxaphene but all three treatments were 99-100% effective after 1 week. In tests on horses, 0.25% sprays of GC-4072 and Dilan, and 0.5% sprays of toxaphene gave 100% immediate control of winter and black-legged ticks but only GC-4072 prevented reinfestation within 1 month.

Field tests indicated that 0.5% toxaphene sprays were slightly more effective against the lone star tick on cattle than any of the newer insecticides. However, excellent immediate control of this species was obtained with sprays of 0.025 and 0.05% Diazinon and 0.5% Dilan and V-C 13. In all cases light to moderate reinfestations occurred in 1-2 weeks. Feeding of ronnel at 7.8 mg./kg. daily for 14 days caused no reduction in tick populations on cattle.

In comparative tests 0.5% toxaphene emulsion applied with a Bean sprayer gave better control of winter ticks on cattle than when applied with a Spray-Foil machine. However, only 1 pint of emulsion was applied with the Spray-Foil as compared with about 1 1/2 gallons with the Bean sprayer.

C. Insecticide Residue Determinations

1. Residue Studies. Research was conducted in Texas and Maryland on the absorption, distribution, storage and metabolic fate of insecticides in animals, using chemical and radiometric methods of analysis.

In Texas a steer given 1.88 mg./kg. orally of C¹⁴ Phosphamidon showed peak activity in the blood in 12-18 hours, in the urine at 4 hours, and in the feces at 24 hours. Little or no activity was detectable after 144 hours. Of the dose received, 71% and 5% was excreted in the urine and feces, respectively. At least 6 metabolites were found but none could be identified. Radiometric analyses did not show significant residues in muscle or fat although the method was sensitive to 1.0 part per billion.

Special tests were conducted in Texas to compare the metabolism of P³² Dipterex in two cows which had shown widely variable results in tests with systemics against cattle grubs. Peak activity in the blood and urine of the two animals occurred at the same time but was twice as high in one as in the other. Over a 3-day period one animal excreted nearly twice as much activity in the urine as the other. A comparison of the metabolites indicated that one animal could destroy the less polar compounds much faster than the other. These differences in

the metabolism of Dipterex indicate that the effectiveness of systemics against cattle grubs may be correlated with the animals ability to metabolize the insecticide.

In Texas analytical methods were developed for determining the amounts of ronnel and V-C 13 in tissues of animals that had been treated with these insecticides. The method was based on the alkaline hydrolysis of the compounds and the determination of the corresponding phenols with amino antipyrine.

In Maryland dairy cattle grazed on pastures treated with as little as 0.25 lb./acre of chlordane still showed small amounts of heptachlor in their milk 8 weeks after treatment. Additional feeding studies with dairy cattle were conducted with corn ensilage containing 1.2, 2.5 and 5.6 p.p.m. of dimethoate. These levels of dimethoate produced only trace amounts in the milk. Fourteen days after being placed on a dimethoate-free diet, no residues could be detected in the milk. In a study with ensilage containing Diazinon no residues could be detected in the milk of cows consuming as much as 500 p.p.m. of Diazinon per week.

2. Toxicity Studies. Studies were conducted in Texas in cooperation with veterinarians of the Animal Disease and Parasite Research Division on the acute and chronic toxicity to livestock of insecticides and other materials applied by different routes of administration. A summary of the results are presented. Detailed results will be given under Unit 2, Animal Diseases and Parasites (ADP a7-11 and ADP a7-12). Extensive tests were run to determine the toxicity of a number of insecticides administered orally, dermally, and by intramuscular injection to cattle. In conventional spray tests with cattle, three of seven insecticides caused no symptoms of toxicity. These materials and the concentration used were Bayer 34727 at 0.25%; Stauffer R-1504 at 0.5% and Rhodia 9895 at 2.0%. One of three animals was affected by a 0.5% application of Bayer 39193. In pour-on tests Bayer 37342 at 2.0% (125 ml.), Bayer 37342 and Bayer 34727 at 2.0% (250 ml.) and GC-4072 at 1.0% in oil (250 ml.) produced no symptoms of toxicity. GC-4072 at 1.0% in water, Bayer 37341 and Stauffer R-1504 at 2.0%, affected some animals and not others. When given orally in capsules to cattle, the following materials were nontoxic: Bayer 37341 and Bayer 37289 at 10 mg./kg., Hercules 9699 at 13.4 mg., Stauffer N-3047 at 15 mg., Bayer 39193 and Stauffer N-2310 at 50 mg., and Neguvon and Rhodia 9895 at 100 mg./kg. Several other materials were toxic to some animals at the dosage tested. In similar tests with calves, 4 of 7 materials were nontoxic at low test dosages but toxic at higher dosages. No toxic symptoms were evident in cattle given 10 daily dosages of the following compounds in feed: V-C 13 at 3 mg./kg., Neguvon at 5 mg.; GC-4072, Baytex and Stauffer R-1504 at 2.5 mg., and Butonate 20852 and Famophos 25644 at 10 mg./kg. Butonate, Bayer 37341, Bayer 34727, and Rhodia were toxic to some animals. Special tests were run

to determine the effects of Dibrom mist sprays as applied to the heads of cattle in controlling the face fly. Repeated applications of approximately 64 cc. of 1.25% and 24 cc. of 1.04% Dibrom produced ocular discharges in most of the animals and opaque spots on the eyes of several.

During the year a number of promising insecticides were applied at high concentrations (5-10%) with a chromatography sprayer at the rate of 100 ml. per animal. Seven compounds caused no obvious toxic symptoms but several lowered the cholinesterase (ChE) of treated animals.

D. Biological Control

In Nebraska large scale releases of the pupal parasites were initiated early in June and continued until early fall at the stockyards in Omaha and in a 36 sq. mile farm area near Lincoln in an effort to control stable flies. The percent parasitism was low during the first month of releases and varied greatly (0 to 100%) from week to week but the average level of parasitism apparently was sufficient to keep populations at a subannoying level throughout most of the season. The parasite Spalangia muscidarum was most effective in dense, compact breeding habitats, whereas Muscidifurax raptor was most effective near the surface of breeding sites.

E. Insect Sterility, Attractants, and Other New Approaches to Control

1. House Fly. Studies in Oregon indicated that irradiation of resistant house flies with sub-sterilizing doses of 1000 r did not alter their susceptibility to insecticides or esterase activity. Treated females mated with untreated males oviposited normally but only 45% of the eggs hatched. Additional studies were conducted with normal and parathion-resistant flies that had been irradiated as pupae with 600 r for 7 generations. Only about 25% of the eggs hatched from matings of irradiated males and females of either colony. No changes in insecticide susceptibility or esterase activity were apparent.

Extensive research on sterilization, attractants and other new approaches to control of the house fly was conducted at Orlando, Fla., in connection with the control of the house fly in dairy barns.

Irradiation caused greater damage to early (2-4 days old) house fly pupae than to middle-age pupae. Virtually no damage was apparent in old pupae and longevity of adults was greater than that of younger pupae. Irradiation of pupae 0-36 hours before adult emergence did not produce complete sterility and some recovery was indicated since second matings resulted in a slight increase in progeny. No recovery occurred in pupae irradiated 72-96 hours before adult emergence.

Extensive studies were conducted to find materials that will induce sterility or otherwise affect the growth and development of the house fly. Of about 1300 compounds tested in the adult food, 21 caused sterility in flies. Only one of about 800 materials tested in the larval media caused sterility but nearly one-third were toxic to the larvae. In secondary tests with 59 compounds that had shown promise in screening tests, twenty-seven caused sterility (no oviposition or hatch) at concentrations of 1% or lower. Additional tests were run with 50 promising materials applied as larval dips, topically to adults, and in the adult food. None caused sterility as larval dips but in adult food, six induced complete or nearly complete sterility. Two other materials were effective only as topical applications.

Special tests were run with 24 promising chemosterilants to ascertain the effects on each sex. Only one material, an aziridinyl compound, caused sterility in both sexes. Methiotepa, 5-fluoroacetic acid, metepa and a confidential material caused complete sterility in males but not always in females. Three materials - 5-fluoroacetic acid, an aziridinyl compound, and 5-fluorouracil - were effective when fed to both sexes.

Studies were conducted to learn more about the action of several effective chemosterilants on house fly sexual development, mating and reproduction. In one series of tests, males sterilized by feeding 3 days on apholate proved fully competitive with normal males when placed with normal females. When only treated males were placed with normal females all eggs were sterile and 12.5% were sterile when only normal males were present. When normal females, normal males, and treated males were combined at ratios of 1:1:1 and 1:1:2, 65 and 80% of the eggs were sterile and higher ratios of 1:1:3, 1:1:5, and 1:1:10 resulted in 99.9-100% sterility. Additional tests at these ratios confirmed that actual sterility was higher than the expected. Males given food containing 0.4-1.0% apholate for 3 days were sterilized for life but lower concentrations of 0.1-0.3% were not 100% effective. Exposures of males on residues of 500-1000 mg./kg. of tepa on plywood panels caused only partial sterility (12-72%) but when applied at 250-500 mg./sq. ft. with sugar tepa and apholate produced 91-100 and 99-100% sterility, respectively. When applied in glass jars, residues of 250 mg./sq. ft. of tepa or metepa completely sterilized flies in 2-4 hour exposures for 30 days but not for 60. Deposits of 100 and 50 mg./sq. ft. caused complete sterility for 14-30 and 14 days, respectively, but deposits of 10-25 mg. were mostly ineffective. Baits containing 0.5% of tepa and metepa effectively sterilized flies after aging 30-37 days on most types of surfaces. Some loss in effectiveness in tepa was apparent on metal and masonite and in metepa on wood, but none was apparent on painted wood, asphalt, metal or wax paper.

Weekly applications of cornmeal bait containing 0.5% tepa on an isolated refuse dump reduced adult house fly populations from 47 to 0 per

grid count in 4 weeks and counts remained at 0 as long as the bait was distributed. The viability of eggs of female flies declined from 100 to 10% in 4 weeks and to 1% in 5 weeks. After baiting ceased, populations increased slowly but the percent viability of eggs was normal after 2 weeks. Additional small-scale field tests with cornmeal-chemosterilant baits against flies were conducted on a small garbage dump and in a poultry house. Weekly applications of apholate bait on the dump and of metepa baits in the poultry house caused some sterility and reduction of fly populations. Applications 5 days a week resulted in a high degree of control and high sterility in flies in both areas. Sterility among females was slightly higher than in males.

Comparative tests showed slight differences in the competitive ability of male flies given 1% apholate in food and those irradiated with 2850 r. Neither radiation nor the apholate completely sterilized the males but at a 4:1:1 ratio chemosterilized males caused a reduction in egg hatch of 81.4% as compared with 78% for the irradiated males.

2. Mosquitoes. In Oregon studies were conducted with a number of chemosterilants. Unfed virgin female Culex tarsalis from 1 to 6 days old did not produce eggs after being sprayed with 5% aphoxide. Adults feeding on sugar containing 0.1% apholate were completely sterilized. Females produced from larvae exposed in 1 to 3 p.p.m. of aphoxide laid numbers of viable egg masses but at 10 p.p.m. very few eggs were produced and viability was less than 1%. Adults emerging from water containing 10 p.p.m. of apholate did not lay viable eggs. Female mosquitoes were sterilized by feeding on mice which had received oral doses of 10 mg./kg. of methaphoxide or 50 mg./kg. of apholate but lower doses were not effective. Maximum effects were apparent only in adults feeding from 15-60 minutes after the mice had been treated. Studies with a radioactive chemosterilant showed that the material was rapidly absorbed by mosquitoes and mice.

Studies were also conducted to determine the effects of irradiation on various stages of Culex tarsalis. Dosages required to kill 100% of the various stages were as follows: Eggs, 800-1000 r; larvae, 150,000-180,000 r; pupae 80,000 r; and adults 100,000 r. Sterilizing doses were 5000 r for females and at least 10,000 r for males. Doses up to 15,000 r had no effect on adult longevity but 25,000 r was definitely harmful.

Approximately 200 chemicals and other materials were tested at the Oregon station to determine whether they would repel or attract oviposition by Culex pipiens quinquefasciatus or C. tarsalis. Several materials attracted more oviposition than distilled water but hay infusion was the most effective. A number of materials apparently were repellent and prevented oviposition by females. The most repellent materials were emulsifiers, the best of which were effective at only 2.0 p.p.m. Over 100 chemicals and other materials, including sex

extracts, were evaluated as attractants for C. tarsalis and C. pipiens quinquefasciatus. None of the materials was as attractive as the carbon dioxide standard.

3. Stable Fly. In Texas a large number of chemicals were evaluated by several methods as chemosterilants against the stable fly. The most effective sterilants were apholate, aphoxide, methaphoxide and crotonamide. Topical applications of 1.8-3.7 ug. of apholate to newly-emerged flies had no effect on oviposition but viability was low (0 to 4%). Similar applications to 6-7 day old flies reduced egg viability to 2%. The sterilizing dosage was slightly less for males than for females. Flies exposed for 48 hours on residues of 10 mg./sq. ft. of apholate on glass oviposited normally but none of the eggs hatched. The residues were effective for 22 weeks. Flies exposed for 1 hour on a residue of 100 mg./sq. ft. of apholate were completely sterilized. Apholate and other sterilants were more effective on glass than on wood surfaces. Stable flies fed on blood containing 0.25 and 0.5% apholate and aphoxide and 0.125% methaphoxide oviposited normally but none of the eggs hatched. Feeding of 0.05% crotonamide did affect oviposition but only a few of the eggs hatched and none of the larvae survived to maturity. Low concentrations of 0.001-0.002% of these 4 sterilants in larval media had no deleterious effect on larval survival or development. Larvae dipped in concentrations of 0.1 and 0.5% survived but their development was retarded.

In Texas selected chemicals and other materials were tested as stable fly attractants. None, including sex extracts, proved attractive.

Studies were initiated in Florida and Maryland on the development of physical and mechanical methods of controlling stable flies, with particular emphasis on radiant energy. Tests were conducted to develop suitable techniques for studying the response of the light and for handling the flies. The flies were equally attracted to BLB, BL and daylight fluorescent lights. The rate of attraction was not affected by changes in light intensity. Maximum response occurred near the end of the dark part of the photoperiod, indicating that a "physiological clock" may exist in flies.

4. Face Fly. In Nebraska about 200 chemicals and other materials were tested as attractants for the face fly. None of the materials were as attractive as fresh feces of cattle. Efforts to isolate and demonstrate sex attraction were unsuccessful. Preliminary studies showed that aphoxide effectively sterilized the face fly. When both sexes were fed sugar containing 0.25% aphoxide for one day or 0.0025% for three days oviposition was reduced and the eggs did not hatch. Normal females mated with males fed for 3 days on 0.005% aphoxide produced only non-viable eggs.

5. Screw-worm. The following studies were conducted at the Kerrville, Tex., laboratory. Over 250 compounds were screened as chemosterilants by several methods against various stages of the screw-worm. About 50 of the materials caused complete sterility by one or more methods of test. Nearly all of the effective sterilants were confidential materials which cannot be identified by name or structure at this time. Known materials causing complete sterility were: Apholate, aphoxide, tretamine, methaphoxide, applied topically and in adult food; colchicine, 2,6-diaminopurine and morzid in food; and metapside and Thiotepea applied topically. One material (confidential) was effective as a sterilant in the larval media but was ineffective by other means of application. Some of the active materials sterilized either sex; others were effective only when both sexes were treated; and others were effective only on one sex. Tretamine and a number of other materials sterilized all ages of flies but certain chemicals were effective only against newly-emerged flies.

There was no consistent difference in the effects of 1000 and 5000 r administered as a single dose or two equal doses. Female flies 3, 4, and 5 days old differed greatly in radiation sensitivity but dominant lethals were induced in the oocytes of all ages. In additional tests with 5-day-old pupae, which have only oogonial cells, the number of eggs deposited by females decreased as the radiation dose increased, indicating that damage to some cells were eliminated from the germ line and were not rapidly replaced.

Over 200 chemicals and other materials were screened for attractiveness to the screw-worm fly by special olfactometer procedures and by exposing the chemicals in beakers in cages of flies. In olfactometer tests isovaleraldehyde was 10 times as attractive as liver (standard), but it was less attractive than liver in beaker tests. Several additional materials were as attractive as liver but none was superior. Light increased attractiveness and maximum attraction occurred at 95°-106° F. Materials exposed at 86°-113° attracted 2 to 3 times as many flies as when exposed at 67°-80°. Very few flies from 1 to 3 days responded to attractants. Highest attraction occurred when flies were 3-4 days old.

6. Ticks. Preliminary tests were conducted in Texas to study the effects of several known chemosterilants on tick molting, longevity, and reproduction. Engorged lone star tick larvae dipped in 1.0% apholate molted to nymphs and then to adults but those dipped in 0.5% aphoxide, tretamine and metepa failed to molt to nymphs. In similar tests in which engorged nymphs were dipped in 0.5% solutions the percentages molting were as follows: Apholate, 45; aphoxide, 70, and tretamine and metepa, zero. All unfed female ticks dipped in 1.0% solutions of these four materials failed to engorge. From 40-60% of those dipped in 0.5% solutions engorged but data are not yet available on the sterilizing effects of the materials. The females dipped in apholate required 15.5 days to engorge but those dipped in other materials engorged in about the same time (11.2 days) as control females.

Irradiation at the rate of 1000 r had no effect on the molting of unfed or engorged nymphs of lone star ticks. However, a dose of 2500 r prevented molting of unfed and 1-day engorged ticks and only 3% of those engorged 1 week molted to adults.

F. Evaluation of Equipment for Insect Detection and Control

1. Sprayers. In Texas, in cooperation with the Agricultural Engineering Research Division, one series of tests was conducted to compare the efficiency of a conventional (Bean) sprayer with that of a Spray-Foil sprayer in applying insecticides to cattle. The Spray-Foil machine gave slightly less control of ticks than the conventional sprayer. However, the Spray-Foil machine applied only one-tenth as much spray per cow as the conventional sprayer. With an increase of two-fold in output the Spray-Foil machine would probably give as good results as the conventional sprayer.

2. Mechanical Devices. In Maryland studies were initiated to evaluate available models of light traps, insect electrocutors and other mechanical devices for the control of flies and other insects. Primary emphasis has been given to comparing the attractiveness of different kinds of light and different intensities. Special test chambers were developed for this purpose. None of the devices tested proved highly attractive or effective. Further tests of existing equipment and efforts to develop more efficient traps and other devices are in progress in cooperation with the Agricultural Engineering and Animal Husbandry Research Divisions of ARS.

G. Insect Vectors of Diseases

1. Anaplasmosis. Studies were continued in Maryland, Mississippi, Texas, and Oregon in an effort to correlate the presence and abundance of insects and ticks with the incidence of anaplasmosis in herds of cattle. All of these studies were conducted in cooperation with the Animal Disease and Parasite Research Division and veterinarians of the various State Experiment Stations.

In Mississippi daily applications of synergized pyrethrins sprays (0.05% pyrethrins + 0.5% synergist) with an automatic sprayer gave complete control of horn flies and significantly reduced attacks by horse flies. The effectiveness of the spray was reflected in a very low incidence (4 cases) of anaplasmosis in the treated herd as compared with that (18 cases) in the control herd. The 4 cases in the treated herd were mild, whereas there were a number of acute cases in the control herd and two animals died. The fact that first transmission in the treated herd did not occur for two months after the first case developed in the control herd serves as a further indication of the effectiveness of the sprays in protecting animals from biting flies. In another test, daily feeding of aureomycin at the rate of 0.5 mg. per

pound of body weight reduced the transmission of anaplasmosis even though no effort was made to control biting flies. Only 4 cases of the disease developed in the antibiotic herd compared with 11 in the control herd. The first case in the treated herd did not occur for over two months after the first one in the control herd.

In Texas monthly surveys were continued to determine the identity and abundance of external parasites on infected (anaplasmosis) and isolated clean herds of cattle. Small numbers of lone star ticks, ear, and black-legged ticks and moderate numbers of the winter tick were present on cattle in January. Populations of the lone star tick increased steadily during February and March, but populations of other ticks were low. First horn flies appeared in March. During April, May, June and July cattle were heavily infested with lone star ticks and horn flies and with small to moderate numbers of ear tick. Populations of all these species were low during August and September. In October the winter, ear, and black-legged ticks and horn flies and grubs were present in small numbers. Moderate to high populations of the winter and ear ticks and grubs and small numbers of black-legged ticks were noted during November and December but no flies were observed on the cattle. No transmission of anaplasmosis has occurred in the isolated clean herds although no effort has been made to control potential insect and tick vectors.

The Oregon station continued surveys in Wyoming from spring to fall to determine the distribution, abundance and seasonal occurrence of potential arthropod vectors of anaplasmosis on several experimental herds of cattle on the Myers' Ranch. The tick, Dermacentor andersoni, a known vector of anaplasmosis, appeared early in the spring, reached a peak population in May, declined gradually thereafter, and virtually disappeared by August. Light to moderate populations of several species of lice were present on cattle throughout the season. Horn flies and numerous species of mosquitoes were present in small to large numbers from May until the advent of cool weather. About 12 species of horse flies and deer flies were present in small numbers throughout the summer. Negative susceptible cattle have developed very few cases of anaplasmosis despite the presence of ticks and other vectors. It therefore appears that natural transmission of anaplasmosis rarely occurs under the Myers' Ranch conditions.

Studies were continued at Beltsville, Md., on the transmission of bovine anaplasmosis. Further attempts to demonstrate transovarian passage of the anaplasma agent in Dermacentor andersoni were negative. When unmated males were forced into hibernation, the survivors readily transmitted the disease 6 months and 3 weeks after engorging on infected cattle. The unmated males survived longer than mated males under hibernation and normal colony conditions. None of the mated males survived hibernating conditions. A series of D. andersoni specimens taken from cattle in the experimental areas on the Myers' Ranch in Wyoming

were tested on splenectomized calves. None of the ticks transmitted anaplasmosis.

Progress was made in studies on the anaplasmosis organism in ticks, using fluorescent antibody, electronmicroscopy, and conventional staining and histological techniques. Structures believed to be the projection part of the organism were demonstrated in the gut and feces smears by the fluorescent antibody technique. These structures were also found by electron microscopy in feces smears.

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EQUIPMENT AND BUILDINGS USED IN PRODUCING DAIRY PRODUCTS
Agricultural Engineering Division, ARS

Problem. Economic conditions are causing farmers to step-up their efforts to reduce production costs and improve quality by reducing labor and modifying environment in livestock production. Labor is an important element in production costs. How to make better use of equipment and to adapt existing buildings and other facilities for more efficient production as herds are increased in size and farms consolidated are major considerations. Cost of replacement or major improvement of existing buildings that are not suited to modern production methods are serious obstacles. Principles, examples, and techniques for planning more efficient operations are needed both by farmers doing their own engineering and by those on whom farmers depend for advice.

USDA PROGRAM

The Department has a continuing program involving engineers and architects conducting basic laboratory investigations, application of laboratory results to a production basis, and development of typical plans for livestock structures. The work is in cooperation with the AH, ADP and ENT Divisions of ARS, USDA, and State Agricultural Experiment Stations, and contributes to Cooperative Regional Projects NC-23, "Farm Structures to Meet Environmental Requirements of Dairy Cattle, Swine, and Poultry," and S-49, "Genetic Methods of Improving Dairy Cattle for the South." Development work on building plans is cooperative with all the State Agricultural Experiment Stations and Extension Services.

Dairy cattle environmental and bio-engineering studies are conducted in a climatic laboratory at Columbia, Missouri, in cooperation with the Dairy Husbandry and Agricultural Engineering Departments of the Missouri Station. AH, ARS, serves in an advisory capacity. Field studies in a hot humid region are conducted at Tifton, Georgia, with the Georgia Coastal Plain Experiment Station and AH, ARS, cooperating. The influences of building arrangement, equipment, and chore routines on the amount and drudgery of dairy chores and means of improving these factors are conducted in cooperation with the California, Maryland, and Minnesota Agricultural Experiment Stations. Typical plans for dairy structures are developed at Beltsville as part of the Cooperative Farm Building Plan Exchange. The Federal part of the program described in this paragraph involves about 3 professional man-years.

At the Washington State Experiment Station equipment and control for automatic feeding of livestock is under development and work on performance characteristics of upright-silo unloaders is in cooperation with the Minnesota State Experiment Station. This work is applicable to both beef and dairy feeding operations. The Federal effort amounts to 3.6 professional man-years.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported 2.7 professional man-years on dairy buildings, an estimated 4.3 professional man-years of research on equipment for environmental control in livestock buildings and 4.1 on dairy equipment. Part of this work is in cooperation with USDA.

Dairy building studies are in progress to determine the relative merits of various systems of handling the dairy cow. Carefully controlled laboratory investigations are being conducted to develop data on the effect of environment upon the comfort, breeding efficiency and production of dairy cattle and to relate such data to housing needs. These studies are a part of Cooperative Regional Project NC-23.

Investigations to analyze and to develop and test equipment for systems to mechanically feed and service beef and dairy cattle, swine, and poultry are in progress. These studies involve the design and installation of automatic feeding systems for blending mixed rations and roughages according to various levels of production and the removal of waste materials. Included also are investigations to determine the necessary specifications and functional requirements for improvements in a mechanical system for removal of chopped hay and silage from storage and its transport for animal feeding. These studies are a part of cooperative Regional projects NE-13, "Studies of the physical properties, behavior, and forms of forage as related to engineering application," and NC-48, "Development of materials handling systems for North Central farms." Research is underway to determine the operating characteristics of various conveying systems and forage and silage unloading devices and to determine the functional requirements and design of automatic controls for an integrated system for livestock feeding operations. The primary objective of these studies is to arrive at suitable methods and equipment to reduce the labor now required and thus reduce unit cost of production. Some similar work on equipment for swine, poultry, sheep, bees, and milk equipment is conducted in various states.

Industry and other organizations. Most manufacturers of "on-the-farm" equipment for livestock and poultry are engaged in testing the performance of their product design and developing improved products. Some are also investigating farm application of products designed for other uses and a lesser number are developing new equipment or methods to meet specific problems in the livestock and poultry industry on farms. Feed grinders suitable for hard corn in Kansas, for example, are not necessarily satisfactory for soft corn in Minnesota. Research is often conducted on a cooperative basis with electric utilities and with State Experiment Stations to save costs and to obtain nationwide results in testing equipment under a variety of conditions and crops. Industry maintains close contact with USDA research for information on functional

requirements and performance characteristics for electric motors, equipment and controls: for example, the motor and control requirements for silo unloaders. The estimated annual industry expenditures for research on items specifically for "on-farm" use are believed to be approximately 10 man-years on poultry equipment, 10 on beef equipment, 10-15 on dairy equipment, 5-10 on swine and less than 5 on sheep equipment.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Layouts, Equipment and Facilities for Increasing Efficiency of Dairy Operations.

At St. Paul, Minnesota, basic work in cooperation with the Minnesota Agricultural Experiment Station on establishing time standards for dairy barn operations has been concerned with the search for suitable standards for coordinating data taken under differing conditions. Industrial engineering pace standards are not apropos when attempting to rate many farm operations.

Baled-hay-handling time standards determined on the project have been applied to the investigation of hay shed design. A number of methods for putting hay into pole hay sheds were studied to determine which was the most efficient. The selected method was then used to determine the time per ton required to place the hay in storage in sheds of various lengths and designs.

Also using standard data, the time required to climb a pile of bales each day and distribute the required number of bales was determined and a minum time per cow was established. This analysis indicated that within ordinary limits, time and labor requirements for moving hay are affected more by the width (depth) of the building than by its height or length.

The studies show that the building design causes variations in the time required for putting the hay into storage of about the same magnitude as those which it makes in the time required to feed the hay out. The minimums for both do not necessarily occur in the same design.

A further analysis was made to determine the building costs of these hay storage structures. The complete analysis will be dependent upon a linear programming study which will include the effects of building costs plus the time and labor required for putting the hay into the building and feeding it out.

The establishment of time standards will eventually provide a basis for analyzing feeding and cleaning operations using tractors, self-unloading wagons and other power equipment.

Much work has centered on the development of methods suitable for analysis of building and yard arrangement with the prime effort being directed to the use of scale models and time standards. Investigations into the use of models have established a need for scale-model building components which can be incorporated into building design and location variations to meet a great number of layout requirements. This has been accomplished by the design of components including wall sections, floors and poles which can be assembled into pole buildings of various shapes and sizes for use as resting barns, hay sheds, and so on. Milking parlor layouts have been developed that will allow for model analysis of all possible door arrangements and most currently available equipment. However, a stockpile of models is needed to expedite this work, and as commercial sources have been exhausted all future models must be handmade.

An attempt was made at St. Paul to set up an ideal loose housing design for a herd of 100 milking cows. It was found that while layout principles for the milking herd itself are apparently well-established, similar coordinated principles for young stock and dry cows are seriously lacking. For this reason the effort has been delayed pending making additional models and searching for more information on coordinating all facilities with the minimum of compromise. Working up this ideal layout has given further indication of the value of models for presenting a good, rapid, visual analysis.

At Davis, California, work has continued in cooperation with the Experiment Station, on studies of dairy layouts having herringbone milking parlors. Thus far the results indicate that double-four, double-five and double-six stall parlors are suitable for herds of up to 100 cows. Herds larger than that will require parlors of the double-eight or double-ten size. When the herd size reaches 400 cows or more it will probably require two parlors of this size to eliminate complications and delays in the holding-washing pens, movement lanes and corrals.

Advantage has been taken of a unique opportunity to obtain operational data on a "before-and-after" basis for two California dairies, making rather extensive changes in building layout. The "before" but not the "after" studies have been made. One dairy is moving to a new site where a complete new farmstead is being developed, in consultation with the USDA research, and the herd is being expanded from 150 to 200 cows. This is the second major modification at this dairy within 10 years, and comparative data will be obtained on all three phases -- the original floor level abreast milking room, a double-three elevated stall milking room, and the planned facility. The other dairy, with 400 cows in lactation, is converting from milking in a 60-stall string barn to milking in 3 side-by-side, double-three elevated stall milking rooms constructed in the old string barn.

Studies of chore time and travel in pie-shaped corral layouts were continued in California as such units were built and became available for study.

Bio-engineering Studies of Dairy Cows.

Basic fundamental studies on the relationships between environment and various dairy animal health and production factors were continued in the psychroenergetic laboratory at Columbia, Missouri, in cooperation with the State Station.

Holstein milk production decline at high ranges of temperature and humidity combinations was shown to be correlated quite well with the United States Weather Bureau Temperature-Humidity Index (THI).

For example, a rise in the T-H Index from 75 to 80 would correlate with a decline of about 12 percent in milk production; a rise from 75 to 85 in the T-H Index, with a 25 percent decline. The study also showed that a cow producing 50 pounds of milk/day in a 65° F. environment will decline more in terms of pounds of milk/day than will a 30 pound/day cow, when subjected to high temperature-humidity conditions. Water consumption for individual cows increased significantly for all temperature increases; feed consumption decreased significantly in some cows, but not all, depending on the amount of stress the temperature-humidity conditions imposed on the individual cows.

In a controlled feeding study lactating Holstein cows were force-fed during exposure to a stress condition of about 85° F. air temperature in order to prevent normal decline in feed consumption at stress conditions. Analysis of data statistically indicated that high temperature depressed milk production, even though the feed level was maintained the same. At 88° F. air temperature maintaining the feed level above that of animals fed free choice did not increase body temperature enough to be statistically significant.

Preliminary tests in an acclimation study with six cows exposed to an 85° F., 50 percent relative humidity condition, after being at 65° F., 50 percent relative humidity, for 6 weeks showed increasing rectal temperatures for 7 to 10 days. After 8 to 25 days of exposure to the high conditions, rectal temperatures leveled off or decreased in 4 cows, but increased in the other two. Respiration rates maximized after 3 days at the higher condition, then leveled off. Pulse rates declined and were lowest after 11 days at 85° F. but increased almost to their initial level about the 18th day.

The dairy cows brought into the laboratory for the temperature-humidity and acclimation studies were subjected to physiological evaluation tests, standardized with regard to environmental factors, as part of a long-range study of variability among individual cows for development

of selection indices. The responses of the 12 cows tested at a condition of 88° F., 40 percent relative humidity show differences among individuals as great as 40 respirations per minute, 38 heart beats per minute, and 3.4° F. in rectal temperature.

Response of thermally-stressed non-lactating Guernsey cows exposed to chilled wall panels, under a shade with wall surface temperatures varying from 20 to 40° F. was significant at the 1 percent level. The chilled panels were effective in reducing respiration rate, skin temperature, hair temperature, and water consumption, but not effective in comparably reducing rectal temperature.

Field evaluations at Tifton, Georgia, in cooperation with AH and the State Station, on the value of shades versus shades-plus-fans for lactating dairy cattle in hot, humid climates showed no benefit in a pen with fan. Average daily maximum and minimum temperatures during the test period (July 10-September 17, 1960) were 90.2 and 70.6° F. Daily averages of daytime relative humidity and dry bulb temperatures were 63 percent and 85.3° F.

Two pens of 9 Jersey cows each at Tifton were held in dry lot except for milking from June 20 to September 4, 1961. One pen was provided shade only and the second had access to the breeze from a fan and a water spray, as well as shade. The shade in each pen was 16' x 48'. The daytime average temperature was 89.3° F. and relative humidity was 58 percent. There were no benefits to milk production from the fan and spray although the sprayed animals seemed more "comfortable." It was felt that both the spray and the increased air flow were inadequate.

Sixteen typical plans specifically for dairy cattle structures and related equipment and another 7 for either dairy or beef cattle were developed at Beltsville for the Cooperative Farm Building Plan Exchange as follows:

Dairy

3-in-line milking parlor and milkroom	1
Structures and arrangements for loose	
housing enterprises	12
Calf pen, the open type	1
Barns, especially for protective	
shielding from radioactive fallout	2

Dairy or Beef

Feeding and watering equipment	4
Hay storages and feeding shed	3

II. UTILIZATION RESEARCH AND DEVELOPMENT

DAIRY PRODUCTS - CHEMICAL, PHYSICAL AND BACTERIOLOGICAL CHARACTERISTICS; AND DEVELOPMENT OF NEW AND IMPROVED PRODUCTS AND PROCESSING METHODS
Eastern Utilization Research and Development Division, ARS

Problem. Dairying is one of the largest segments of American agriculture: dairy products represent 13.9 percent of all farm cash receipts; milk production requires 140 billion feed units annually; milk is a highly nutritious food. It is clear from these facts that research which succeeds in increasing the consumption of milk will have far-ranging effects in raising nutritional levels, in increasing farmers' income, and in increasing consumption of feeds. There is opportunity to increase milk consumption, for per capita consumption is currently at its lowest point in over 30 years at 622 pounds, whole milk equivalent. Current consumption in the U. S. is well below that of several foreign nations, including New Zealand, Canada, Australia, Sweden, Norway and the United Kingdom.

Increased consumption can result from improved quality of manufactured dairy products, from cost reductions based on improved processing technology, from the development of new products, or from any combination of these. The development of new and improved processes and products is the objective of utilization research on dairy products.

Both basic and applied research in this field are needed; applied research is the direct antecedent to the development of new products and processes, and basic research provides the information which permits applied research to proceed most effectively.

Increased emphasis on basic research has been advocated by the Commission on Increased Industrial Use of Agricultural Products, and the National Agricultural Research Advisory Committee. Basic research is considered primarily the responsibility of public agencies which disseminate their findings for use by all.

One aspect of the problem posed by dairy products is the great need for fundamental information on the complex biophysical-chemical system which each dairy product is. The development of new products and new processing technology through applied research represents the exploitation of fundamental information. Such exploitation and development cannot continue indefinitely; the supply of fundamental information must be maintained and enlarged, and this is the purpose of basic research. The complexity of milk makes necessary the employment of several scientific disciplines in basic research on this commodity. These disciplines undertake investigations needed to identify and measure the amounts of individual chemical components present; the molecular structure of these components; how the molecules react; and the forces which determine the course of the reactions. These studies should be intensified. Other needed investigations include study of

the mechanism of the synthesis of milk; the properties of milk fat; and the factors responsible for the flavor of dairy products and the changes in flavor which occur during processing and storage.

There is also need for a vigorous and sustained program of applied research which is aimed to increase consumption of dairy products. Such a research program could stimulate consumption by development of products with increased palatability, convenience, or extended shelf life. Another opportunity is the possibility of developing new and improved processing technology which will reduce costs. Because the price elasticity of milk and milk products is greater than that of most food crops, cost reduction is an attractive avenue for increasing consumption.

Still another opportunity is the development of new milk products of low fat content, for example, a low-fat Cheddar cheese. Such a development could alleviate problems posed by current controversy over the effect of animal fats in the diet.

Increased consumption, however achieved, should have a powerful upward effect on feed consumption. It is estimated that milk production requires 140 billion feed units annually (a feed unit is the feed value equivalent to a pound of shelled corn). Hence a 1 percent increase in production would require feed equivalent to 25 million bushels of corn--the production of some 500,000 acres. If the feed were supplied by cropland pasture, more than a million acres would be needed.

It is thus manifest that utilization research leading to product and process development can provide a powerful stimulus to American agriculture.

USDA PROGRAM

The Department has a continuing long-term program involving chemists, biochemists, microbiologists, food technologists, and engineers, engaged in basic research on the composition and properties of milk, and in applied research directed to the development of new and improved dairy products and processing technology.

The Department's research facilities are located in Wyndmoor, Pennsylvania, Washington, D. C. and Beltsville, Maryland. The Federal scientific effort devoted to research in this area totals 82.6 professional man-years. The effort is distributed as follows:

(a) Work on composition and physical properties of milk involves 0.5 professional man-year at Wyndmoor, in a study of genetically-caused variation in the composition (and hence the interactions) of selected milk proteins. This work is cooperative with the Animal Husbandry Research Division, ARS. In addition, work sponsored by the Department

under a P.L. 480 grant goes forward at the Centre de Recherches sur les Macromolecules, Strasbourg, France (0.4 p.m.y.) on the structure of nucleic acids.

(b) Work on the isolation, structure and properties of milk proteins, and the interactions of milk components involves 19.5 p.m.y., at Wyndmoor, in pioneering studies of milk proteins and investigations of the reactions of proteins and polypeptides with each other and with other milk components. Cooperation is maintained with the Animal Husbandry Research Division, ARS.

In addition, research sponsored by the Department under P.L. 480 grants is under way at (1) National Institute of Agronomic Research, Paris, France (0.7 p.m.y.) on the activity of rennin toward individual components of casein.

(c) Work on flavor components and flavor stability of milk and milk products involves 7.5 p.m.y. at Washington. In addition, research sponsored by the Department under a P.L. 480 grant goes forward at the Biochemical Institute, Helsinki, Finland (2.5 p.m.y.), on the transmission of flavor components and other biologically-active compounds of feed of dairy cattle to the milk and milk products.

(d) Work on the microbiology of dairy fermentation involves 2.5 p.m.y. at Washington, in fundamental studies of the species, strains and biochemical activities of microorganisms used as starters in making butter, cheese, sour cream and cultured milks. In addition, research sponsored by the Department under a P.L. 480 grant goes forward at the National Institute for Research in Dairying, Reading, England, (0.7 p.m.y.) on differentiation of microorganisms important in dairy products.

(e) Research on the control of spoilage organisms involves 1.0 p.m.y. at Washington, in basic studies of the formation, germination and heat resistance of bacterial spores.

(f) Work on milk enzymes involves 1.0 p.m.y. at Wyndmoor. In addition, research on milk enzymes sponsored by the Department under P.L. 480 grants goes forward at the Instituto Nacional de Technologia, Rio de Janeiro, Brazil (0.6 p.m.y.), on proteolytic enzymes.

(g) Pioneering research on the allergens of milk and other agricultural products involves 4.0 p.m.y. at Washington.

(h) Research on dry whole milk and other dried milk products involves 30.5 p.m.y. at Washington and Wyndmoor. The program includes fundamental and applied research directed toward developing technically and economically feasible methods for producing dried whole milk with instant dispersibility and with flavor which will remain stable during six months storage at room temperature.

(i) Study of improved processing of fluid milk, cottage cheese and associated products involves 1.5 p.m.y. at Beltsville.

In addition, research sponsored by the Department under a P.L. 480 grant is going forward at the Centro Experimental del Frio, Madrid, Spain (0.4 p.m.y.) on protein destabilization in frozen milk.

(j) Research on improved ripened cheeses and cheese technology involves 0.5 p.m.y. at Beltsville. Contract research on improvements in cheese manufacturing technology is being conducted at the Ohio Agricultural Experiment Station, Wooster, Ohio; 0.3 p.m.y. is involved.

In addition, research sponsored by the Department under P.L. 480 grants is going forward at: (1) Institute of Biochemistry, Turku, Finland (0.6 p.m.y.) on growth-promoting factors for lactic acid bacteria in cheese making. (2) Kaira District Cooperative Milk Producers Union, Ltd., Anand, India (0.6 p.m.y.) on addition of non-fat dry milk solids to buffalo milk in the manufacture of hard cheese. (3) Institute of Dairy Industry, Warsaw, Poland (0.1 p.m.y.), on increasing the vitamin B content of cheese. (4) National Dairy Research Institute, Karnal, Punjab, India (0.5 p.m.y.) on milk coagulating enzymes of microbial origin, for cheese manufacture.

(k) Work on improved concentrated milks involves 2.0 p.m.y. at Washington. Contract research is under way at the University of Illinois, Urbana on possible flavor improvements in concentrated milk; 0.3 p.m.y. is involved. Contract research at Oregon State University, Corvallis deals with methodology for evaluating concentrated milks; 0.4 p.m.y. is involved.

In addition, research sponsored by the Department under a P.L. 480 grant is going forward at (1) Stazione Sperimentale del Freddo, Milan, Italy (0.9 p.m.y.), on new food products from concentrated milk and fruit juices suited to European tastes. (2) Institute National de la Recherche Agronomique, Paris, France, (1.0 p.m.y.) on non-protein nitrogenous substances formed from milk proteins during processing. (3) National Institute for Research in Dairying, Reading, England, (0.7 p.m.y.) on the isolation and characterization of selected enzymes of milk to obtain fundamental information useful in improving the quality of dairy products.

(l) Work on improved butter involves 1.0 p.m.y. at Washington. Contract research at Iowa State College, Ames is concerned with the stability of butter and involves 0.2 p.m.y.

(m) Research on the identification and removal of radioactive nuclides from milk involves 9.5 p.m.y. at Beltsville. This is a cooperative program with the U.S. Public Health Service and Atomic Energy Commission, to develop effective ways for removing cationic radionuclides (Sr-90, Cs-137, and Ba-140).

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 67.6 professional man years distributed as follows: chemical composition and physical properties of milk and milk proteins, 10.4; chemical and physical properties of milk fat, 5.2; flavor components of dairy products and flavor stability, 8.5; microbiology of milk and dairy products, 13.2; allergens of milk, 0.3; enzymes of milk, 2.1; dry whole milks and other dried milk products, 5.7; improved processing of fluid and concentrated milk, cottage cheese and associated products, 7.0; improved ripened cheeses and cheese technology, 6.2; improvements in butter, 1.8; improvements in ice cream, frozen desserts and ice cream technology, 4.3; new and improved milk-containing food products, 1.4; utilization of whey, 0.8; removal of radionuclides from milk, 0.9.

Industry and other organizations also conduct research of interest and value on milk and dairy products. Industry is generally dependent on government, university, and other nonprofit institutional research for basic investigations into the chemical, physical and bacteriological characteristics of dairy products. Most of their effort is in development, with more attention given to technological research. Industrial research is being conducted to improve the dispersibility and flavor stability of spray dried whole milk. Industrial research in the fluid milk area is concerned largely with cost savings activities, container testing and low calorie formulation. A continuing program of cheese research is directed toward labor saving and attempts to shorten the ripening period. Industry has sought to develop an improved evaporated milk using the high temperature-short time sterilization process, and has supported work to evaluate concentrated milk in infant feeding. Industry has been active in developing new uses for milk in foods; bakery goods, cereals, confections and sterilized foods containing milk have been formulated. Estimated annual expenditures for industrial research in the dairy industry are equivalent to about 300 professional man-years distributed among at least 18 different company laboratories; estimated industrial expenditures for basic research on milk are equivalent to perhaps 5 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Composition and physical properties of milk.

Genetics and its relation to chemical composition of milk is a new field of research which has great potential possibilities in future improvements of dairy products. Preliminary investigations on milk from individual cows have demonstrated a variation in stability to the development of oxidized flavor at refrigeration temperatures. Variation in the processing behavior of milks from month to month and season to season may in part depend on genetic factors. Some definite

knowledge is now available to show that the amino acid structure of the two known β -lactoglobulins has a genetic cause. Derivatives of β -lactoglobulin have been prepared through chemical reactions which will expedite studies of the structure of this milk protein.

B. Isolation, structure and properties of milk proteins; interactions of milk components.

1. Chemical and physical properties. The importance of milk proteins in milk products is established. Whereas a few years ago these proteins were talked of only as the caseins and whey proteins, now their complexity is becoming fully recognized. Advances in protein research tools permit the realization that milk not only contains a great number of different proteins, but also that they are highly reactive. Heat treatments normal to milk processing produce detectable changes in many of them; some of these changes are responsible for undesirable behavior in dairy products, as gelation in concentrated milks.

The existence of two β -lactoglobulins was confirmed several years ago; the minor differences in amino acid composition are known, and amino acid sequence is partially established.

Recognition of kappa-casein as a milk protein is now several years old; its reported power to stabilize milk concentrates against physical change may prove to be very valuable in designing successful commercial milk concentrates, but more thorough studies must still be made. Recent improvements in procedures for its isolation and purification will make these studies possible.

The presence in milk of an iron-containing protein in equilibrium with an iron-free protein is now established. Significant progress has taken place in the elucidation of the primary structure of α -lactalbumin; through partial hydrolysis with the enzymes pepsin, trypsin and carboxypeptidase followed by careful analysis of the resulting peptide mixtures a significant portion of its amino acid structure is known. Additional data have accumulated on two minor proteins of the casein complex-- β - and γ -caseins.

A neutral protein was isolated from the fat plasma interface region of milk and shown to be highly antigenic. The usual tests for homogeneity indicated that this protein is a single entity.

As the sensitivity of tests for homogeneity improve, purity of some proteins has become suspect. In some cases indications of multiple composition become more frequent; sometimes these are traced to the association or aggregation of smaller unit molecules into polymers.

2. Interaction of milk components. The major goal of utilization research on milk processing is to obtain concentrated or dry milk which will reconstitute to a product as much like fresh milk as

possible. Failure to achieve this goal completely can be attributed chiefly to physical and chemical reactions between the components of milk; some possible reactions are: one protein with another, protein with lactose or protein with fat. Basic research to establish the nature of these interactions is essential to development of successful products.

The casein of milk is a complex mixture of proteins containing phosphates, calcium and citrate; inorganic ions, hydrogen ion concentration and temperature are also intimately concerned with physical behavior of milk products. Attack on this problem has followed two approaches; (1) model systems in which the effect of varying one component at a time is studied; (2) attempts to detect changes in whole milk by refined analytical techniques.

One casein fraction is easily coagulated by an increase in calcium ions; kappa-casein will keep this phenomenon from happening. Investigation of this interaction has been undertaken in the belief that it is vital to the development of understanding of the mechanism of thickening and other manifestations of instability. Polyphosphates also prevent the coagulation of calcium sensitive casein as well as whole milk under sterilizing conditions and subsequent storage. The interactions involved in this behavior are poorly understood. After homogenization of milk at pressures in the 6,000 to 8,000 pound per square inch range, much of the fat centrifuges to the bottom rather than to the top layer; the sediment is a combination of fat and protein. Heat is known to produce reaction of sugar and protein to give colored products; these may also be related to undesirable flavor changes.

C. Flavor components of milk; flavor stability.

Research on the cause of oxidized flavor in dairy products continues not only in the Dairy Products Laboratory but in several other laboratories as well. Contract research with Iowa State University on oxidized flavor in butter established that the offending cause was a compound so potent in producing oxidized flavor that even with the superlative powers of gas chromatography its nature could only be qualitatively identified since it gave no peak on the chromatograph record with the quantities at hand, but issued from the chromatograph with the unsaturated aldehydes containing 7 or 8 carbon atoms. Australian workers have just announced the composition of this compound as vinyl n-amyl ketone, an 8-carbon unsaturated carbonyl-containing substance. This story illustrates the vagaries of flavor research.

Stale flavor is another objectional characteristic which develops in milk powder and evaporated milk after long storage, even in low oxygen concentration. The chemical nature of this flavor is even less well defined than that of oxidized flavor. Utilization research has active investigations in this area both in its own laboratories and by contract. Just as genetics is already known to control the structure of β -lacto-

globulin in milk, so may similar laws control one or more flavor genes in milk secretion. Therefore, for a better understanding of milk flavor the goal may be achieved more quickly with individual cows; but even here factors such as feed and lactation period also have an effect on total flavor. Development of analytical techniques for separation and identification of individual flavor components is progressing satisfactorily; however, the complexity of the problem is such that several years of coordinated effort may be needed to unravel it.

One aspect of research in fluid milk, sterile milks and reconstituted powders that has received little attention is the reaction of the consumer to the different flavors that occur. The industry has an established scoring system with trained tasters. By contract with Oregon State University data on consumer evaluation of milk flavors are being collected on the same samples that will be scored by a trained taste panel.

Preliminary results indicate good correlation between the two types of panel; that is, a sample with a flavor disliked by the consumer will get a low score on a trained panel.

D. Microbiology of dairy fermentation.

Cheddar and cottage cheeses are the major products in this category. The chief problem with these products is need for greater uniformity and for intensification of desirable flavor, a phenomenon resulting from microbial reactions; the chemical reactions giving off flavors so characteristic of milk concentrates and powders are not such serious problems in cheeses. Although several studies on the chemical composition of cheese flavor have appeared, duplication of natural flavor with synthetic mixtures has not been completely successful. Attempts to control the flavor of cheese have been trial and error type experiments. Progress in this area depends upon coordinated basic research--both chemical and microbial--to secure a better understanding of the process which accompanies flavor genesis.

Other developments in cheese technology concern the control of so-called starter failures. Two causes are involved: (1) the use of antibiotics in the control of disease, which may result in contamination of the milk with chemical substances to which certain cheese starter organisms are especially sensitive; (2) contamination of starter cultures with bacteriophage (phage), a disease of microbes. Investigation of this problem in commercial cheese factories has established that phage is the major cause of starter failure and that it can be prevented by the use of special phosphated media for the propagation of starter cultures.

E. Control of spoilage organisms.

For many years the dairy industry has recognized that bacterial spores make necessary the high temperatures needed to sterilize fluid milk

products. If means were available to make these resistant forms of bacteria more labile to heat, then fluid milk products could be sterilized without producing the strong heated flavor which is objectionable to many consumers. If this problem is to be solved, basic research on the nature of the spores' unusual heat resistance must precede their practical control with temperature treatments comparable to those for the vegetative forms of bacteria. One chemical difference between vegetative and sporulated forms of bacteria is the presence in the latter of significant proportions of a compound called dipicolinic acid, a compound not previously recognized as having a part in biological processes. Present research is studying how this substance is tied up with the unusual heat stability of spores.

F. Enzymes in milk.

Milk contains several enzymes; all are sensitive in varying degrees to heat. The lipolytic enzymes produce undesirable flavor changes in homogenized milk unless they are destroyed by a heat treatment. Alkaline phosphatase is the basis of the test for adequate pasteurization of milk.

The Milk Properties Laboratory is investigating the purification of an enzyme called acid phosphatase which, under suitable conditions, particularly of hydrogen ion concentration, hydrolyzes the organic phosphorous bonds of those caseins containing this element. Small amounts of the pure enzyme have been prepared from milk by chromatographic procedures. When more material is available its properties and reactions will be studied.

G. Allergens of milk and other agricultural products.

Many infant ailments are often diagnosed superficially as milk allergy. More sensitive tests for allergic reactions show that the majority of these reported reactions of milk have some other explanation; yet there is an occasional authentic allergic reaction to milk. The Allergens Pioneering Laboratory program concerns the characteristics of the allergens of cow's milk and, where possible, their chemical nature, and how they can be inactivated by commercial processing techniques. The rarity of human subjects who have a real sensitivity to milk allergens and the lack of other suitable methods of study has made progress in this field slow. Recent isolation of a milk protein with strong antigenic properties may expedite this program.

Progress on practical aspects of allergens in agricultural products depends to a considerable degree upon the amount of basic information on immunological processes which is available. A method was developed for the detection of dextran in animal tissues which is based on a phenomenon similar to reversed passive anaphylaxis. Treatment of castor bean or cottonseed allergens with certain chemicals or enzymes modifies their allergenic properties as well as their chemical

composition; however, most treatments leave some residual activity which may, of course, be from a small amount of unchanged original material. Heating castor beans with aqueous calcium hydroxide destroys their allergenic activity and also the toxicity of ricin, a toxic protein in this agricultural product.

H. Dry whole milk and other dried milk products.

Foam drying continues to look promising for preparing easily dispersible whole milk powder of beverage quality. Some technical problems remain, but there is confidence that they will be solved. Further improvement in flavor stability during storage is desirable.

1. Process development. Four methods for the continuous drying of milk foams have been evaluated. Two methods, the vacuum and the spray, warrant further extensive investigation.

A cost estimate for drying whole milk by the spray foam process has been prepared. A similar cost estimate for the continuous vacuum foam drying process has been brought up-to-date. Both estimates are provisional. The estimates suggest that milk dried by either process can be sold profitably in retail stores at a price considerably lower than the average store price for fluid milk. Since in several respects relating to quality there are now important differences between the spray and vacuum dried milks, it is intended to continue research on both drying methods until the evidence is complete enough to allow a sound decision between the two to be made.

Two other methods of drying whole milk have shown little promise on quality or economic grounds and research on them has been terminated. These are atmospheric drying of milk foams on a moving belt ("foam mat drying"), and spray drying in an inert atmosphere.

2. Spray drying. Spray drying is particularly attractive because it is inherently cheap and as conventionally practiced is widely familiar to the milk processing industry. Our own recent experiments designed to spray dry and agglomerate foamed concentrated milk in a single pass through the dryer have been so successful as to give rise to a feeling of considerable optimism concerning this mode of drying. Although the fluid foam is formed by the expansion of inert nitrogen gas incorporated at high pressure into the whole milk concentrate, the drying of the foam droplets is accomplished in a current of hot air. A fine cellular structure is characteristic of the dried particles. In practically all aspects of initial quality, spray dried foams seem to be just about as good as vacuum dried foams. With the existing spray dryer, powders with 3% residual moisture content have been produced at rates up to 400 pounds per hour. The output when drying foams is significantly higher than has been possible in conventional operation.

Although the process as practiced is carried out in air, no adverse

effect on flavor stability from exposure to hot air in the dryer has yet been recognized, and no chemical evidence for oxidative damage to the milk fat has been found.

Important problems to be solved include finding means for: quickly cooling and deoxygenating the dry powder, and packaging it under oxygen-free conditions required for satisfactory flavor storage life; reducing the tendency toward forming a persistent froth on reconstitution; and lessening the variability in keeping quality of powders with seemingly identical origin and history.

Lenthening storage life by controlling development of "stale flavor," and improvement of "self-dispersion" or "spontaneous solution" are problems common to both the spray and vacuum processes.

3. Continuous vacuum drying. Continuous vacuum drying on a moving solid belt has been elaborated from the original batch process for dehydrating whole milk concentrates in the form of a fine-grained foam. Dehydration is relatively rapid--the transit time being of the order of a minute--and is carried on in the virtual absence of oxygen, which minimizes oxidative damage during drying and should greatly facilitate inert gas packaging of the dry foam in a continuous commercial operation. Economic feasibility of this process now appears to require "boildown" of the milk concentrate foam in order to considerably increase the dryer output. The intent of the boildown is to remove most of the water in the milk concentrate through initial violent boiling, after which the residue collapses to a thin fine-grained foam in good thermal contact with the stainless steel belt. From such a foam it should be possible to remove the residual water at a rate which would improve the overall production of dry milk foam to a worth-while degree. Boildown also results in an increase in powder density to 0.35 g./cc or higher, with a resulting large saving in packaging expense. Experience extending over three years indicates that the type of foam instability which permits boildown is a seasonal characteristic, and is manifested to the most favorable degree during the winter months of December and January.

Since controlled foam stability is essential to the success of the boil-down technique in the continuous dryer, a laboratory investigation of milk concentrate foams has been undertaken. A reproducible test has been developed for measuring extent of foaming and foam stability, and correlation of these properties with viscosity, temperature and surface tension has been studied. The effects of various additives are now being determined, as are the effects of the natural constituents which change to an important extent with season when these constituents are artificially varied in amount. Pending a general solution to the problem of controlling boildown, a statistically designed plan for determining the operating variables that will give maximum output from the continuous dryer is in abeyance.

The continuous vacuum process has the distinct advantage of permitting

virtually no exposure of the milk to oxygen from pasteurizer to package. At present, the continuous dryer is equipped only to deliver dried milk to polyethylene bags in a vacuum tight receiver. An enclosed packaging apparatus has now been built which will allow transferring the milk powder, by means of nitrogen-filled bags, from the receiver into a chamber filled with nitrogen, and comminuting and canning the powder in the inert atmosphere. The effect of this refinement on flavor stability will be tested. The apparatus will also be used in determining the practicality of several methods of in-package oxygen scavenging for reducing the level of residual oxygen still more.

4. Quality improvement. One of the essentials for preserving fresh flavor in foam-dried milks is storage in the almost complete absence of oxygen. A novel method for achieving and maintaining a "zero-oxygen" level over milk powder is being investigated extensively. The principle of the method is the in-package catalytic combination of oxygen with hydrogen by palladium at ordinary storage temperatures. The catalyst is a small pellet containing a few hundredths percent of palladium on a highly porous inert support. The cost appears to be economically feasible. In our experience reduction of headspace oxygen over canned spray dried milk foam from 1% to 0.003% by means of in-package hydrogen-palladium catalyst requires no more than a few hours at room temperature.

Development during storage of a stale flavor much like that of old evaporated milk continues to be our most annoying flavor problem in samples of whole milk powder packaged with an inert gas. This stale flavor is qualitatively distinguishable from the stale flavor sometimes found predominant in nonfat milk powders. "Whole milk powder stale flavor" presumably arises in great part from the milk fat, although the reactions that take place and the participation by proteins, milk sugar and other components are unknown. No means for preventing stale flavor development during storage is now apparent, except for use of impractically low temperatures. Although exposure to water vapor promotes the stale flavor development, drying of milk powder to an abnormal extent has not yet resulted in a worth-while inhibition. An experiment in which whole milk powder is stored in the virtually complete absence of moisture will, it is hoped, show what potentiality exists for controlling stale flavor through the residual moisture content in the milk powder.

Increasing thought is being given to involvement of minor lipids, possibly originating in the rumen, which are precursors to off-flavor imparting substances by reactions in which oxygen does not participate.

In empirical attempts to improve flavor characteristics, variously purified and fractionated milk fats have been emulsified with skim milk concentrate and foam dried. Powders made with milk fat which had been deodorized or purified by steam or chemical treatment have not yet shown significantly improved storage stability. However, powders made

with the fraction of milk fat which is fluid at 70° F. have maintained superior flavor scores in a limited number of tests. This inquiry will be continued and broadened. Although it is possible in practice to prevent oxidized flavor from developing in dry milk by rigorous exclusion of oxygen during production and storage, it may be desirable to incorporate positive protection from autoxidation in order to extend the shelf life after the container of milk powder is opened to the air, as well as to reduce production and packaging costs. Hence our continuing interest in added and self-developed antioxidants. A measure of success in securing antioxidant activity has been achieved both by mildly heating all of the milk to be dried and by adding a small proportion of much more strongly heated whole or skim milk concentrate to the remainder of the milk to be dried. The effective antioxidant so produced is not known and its identification may be a worth-while research endeavor. Mercapto groups derived from serum proteins are often identified, very likely incorrectly, as the active antioxidant. Low molecular weight sulfur compounds probably contribute most to the moderately objectionable "cooked" flavor which develops at the same time but not necessarily at the same rate as the desired antioxidant property.

Because milk fat is implicated in the more important off-flavors, it is of interest to know to what extent the keeping quality of milk powder can be improved by reducing its fat content. Our observations show that over the fat content range from about 14% to 40%--the normal is 26%--there is no important difference in flavor stability. With a fat content in the powder of less than about 14% the reconstituted milk is, to the palates of most people, deficient in whole milk character to an unacceptable degree.

An attempt is being made to obtain through contract a meaningful expression of consumer reaction to types and intensities of off-flavors which develop most frequently in whole milk powders, in order to evaluate the scoring system which the trained taste panels use. The off-flavors of greatest concern are "stale," "oxidized," "cooked," and "astringent."

To assist in the investigation of factors which affect quality characteristics such as ease and completeness of milk powder dispersion, persistence of froth on reconstitution, and variability in the tendency to develop off-flavors on storage, a simple all-glass apparatus has been built in which vacuum dried foams can be made from as little as a pint of milk. A striking observation made possible by this apparatus is that some powders prepared from the milk of individual cows have very good flavor immediately on removal from the dryer, but show off-flavor to a serious degree when tasted after exposure to air for as little as three hours. Other individual milk powders retain completely their initial fine flavor.

5. Structure and dispersibility. Work on the protein factors which relate to the dispersibility of milk powders has continued. Attempts

are being made to characterize the configurational changes in molecules of the casein fraction during uptake of limited amounts of water which result in loss of milk powder solubility. Apparently a low molecular weight protein dissociates during this destabilization process. Additional evidence was obtained which shows that foaming milk brings about a partial fractionation of micelle constituents, with lower molecular weight material moving into the films of the foam. A study is being made of the effect of oxidation on the constituents of the casein micelle, and the role of phospholipids in the stabilization of the micelles during dehydration and rehydration is being investigated.

Gas adsorption studies were carried out to determine the specific surface area and capillarity of surfaces produced by various drying methods. The results when compared with results of permeametric measurements, revealed that only "instantized" skim milk powders possess surfaces characterized by capillary-like pores or crevices. The "free fat" globules of foam dried whole milk contribute appreciably to the surface area. Foam dried whole milk has a high specific surface area relative to foam dried skim milk. Fluorescence microscopy was used to determine the state of the fat in the interior of foam dried milk powder particles. Cross sections of plastic-embedded milk powders show the fat globules to be distributed more uniformly in foam dried milk than in conventional spray dried milk.

A method was developed, based on x-ray diffraction, for measuring the crystalline lactose content of milk powders.

A unique surface-active protein is present not only on the surface of the fat globules but also in the plasma of milk. The distribution of this protein in milk and the changes in distribution during the production and reconstitution of dry whole milk are under study. The protein contains a carbohydrate moiety which includes a high level of neuraminic acid, a compound of great interest in biochemistry. A non-dialyzable fragment has been isolated which contains almost equal amounts of carbohydrate and peptide. The fragment is being analyzed for its amino acid composition and immunochemical similarities to the glycomacro-peptide of casein.

I. Improved processing of fluid milk.

Since fluid milk consumption represents about one-half of total milk production, any improvement in quality can easily lead to a significant increase in consumption. The introduction a few years ago of vacuum deodorization treatment to remove volatile feed or weed flavors gave a better fluid milk; however, pasteurization was performed in a separate step. The Dairy Products Laboratory has designed and successfully demonstrated equipment which pasteurizes and deodorizes milk simultaneously. This product has superior storage life in the refrigerator as compared with pasteurized raw milk. At least one manufacturer of dairy plant equipment has this design of equipment available

for installation in commercial dairy plants; some units have already been installed.

The decline in milk consumption and reasons proposed to account for this emphasize the need to make available to the consumer fluid milk of different composition than that of whole or nonfat milk. Technical knowledge to produce such products has been tested successfully; commercial interest should be stimulated.

J. Improved ripened cheeses and cheese technology.

Emphasis in cheese research has continued to stress basic chemical and bacteriological studies on the nature and development of the desirable flavor in Cheddar cheese, including composition and propagation of conventional and supplemental starters, lipolytic enzymes and means for controlling bacteriophage. Commercial enzymes--proteinases and lipases--were added individually in cheesemaking. No improvement in flavor or texture was found with proteinases. Rancid and unclean flavors developed with some lipases, such as steapsin. The addition of mildly lipolytic supplemental cultures to cheese milk and the controlled development of rancidity in the milk intended for cheese starters are the only means that have continued to show promise of increasing cheese flavor.

The phosphated nonfat dry milk is an effective control for bacteriophage in cheese manufacture and should result in significant savings for the industry. Cheese whey, especially that from cottage cheese, has been a problem to the industry for many years. Economical utilization has succeeded only for a small portion of the available products; disposal has entailed additional costs. A feasible process for production of yeast from whey was developed earlier. Recent animal feeding experiments by Pharmacology Laboratory, WU, have shown that this yeast from whey is equivalent to other food yeasts. This should open up profitable outlets for an additional portion of the available whey. Better utilization of whey requires its conversion to a dry product in order to minimize transportation costs. With cottage cheese whey this has not been possible due to its high acid content. A new process for drying whole milk also converts whey to a very attractive free flowing powder.

There is a definite need for low fat dairy products to satisfy those consumers who are diet conscious or who may have to avoid fats for some other reason. A skim milk cheese with the flavor characteristics of Cheddar cheese should find a ready market. Two problems remain unsolved in achieving such a product; the body and texture of experimental preparations made to date are not acceptable; nor has an attractive flavor of good Cheddar cheese been obtained as yet.

In several investigations dairy chemists have studied the composition of Cheddar cheese flavor. Other research indicates that the good

flavor of Cheddar cheese arises from the fat. Only by further research can it be established whether a low fat cheese can be developed with the customary desirable flavor.

In the manufacture of cheese, milk is usually coagulated with the enzyme rennet. To clarify its action on α -casein methods are under study for hydrolyzing quantitatively the carbohydrates from the glyco-macropeptide resulting from the enzyme action. Heating for one hour in dilute sulfuric acid (pH 2), the usual procedure, did not hydrolyze the carbohydrates quantitatively.

K. Improved concentrated milks.

The previously announced discovery that some polyphosphates inhibit gelation in concentrated milks is believed to represent major progress toward solution of the physical instability problem which has been a serious hindrance to successful commercialization of high temperature-short time sterilized milk concentrates. With further experimentation since the initial discovery, facts are coming to light which show that the polyphosphates do not always stabilize milks against coagulation during the sterilizing treatment; partial hydrolysis of the polyphosphates to orthophosphate is a factor in this phenomenon. In non-sterile refrigerated and frozen milk concentrates stability to heat is not an important factor. The evaporated milk industry is actively studying the practical use of polyphosphates. Elucidation of the mechanism of the polyphosphate effect is under study in EU.

The importance of the fat-water interface to the physical stability of milk concentrates has been recognized for a long time. Research on this indistinctly defined area of milk has posed difficult experimental problems. A basic study of the effect of individual milk proteins on the energy relationships at this interface, as measured by surface tension, is contributing to knowledge from which better milk concentrates can be designed. The mucoprotein recently isolated from the fat globule membrane of milk also has a stabilizing influence in concentrated milk; other milk proteins, especially kappa-casein, likewise influence the physical stability of milk products and are still receiving research attention.

Flavor deterioration in concentrated milks usually results in a defect characterized as stale. Through a contract with the University of Illinois the chemical nature of this stale flavor is being investigated. Progress in this field is not as advanced as that on oxidized flavor. A more efficient procedure for separating the flavor from the product is badly needed before more rapid progress can be made in its identification.

L. Improved butter and milk fat products.

At the present price of butterfat there is some agreement among industry

and government representatives that butter will become an increasingly serious surplus problem unless some way is found to raise its consumption as human food. Foreseeable means to achieve this goal by research, even if successful, may hardly be sufficient to keep up with increases in the annual surplus. In cooperative research with EU the University of Maryland has investigated the best source of fat for ice cream. The product called concentrated sweetened cream, which was developed in DPL as a substitute fat source for frozen and other forms of cream, has been carefully studied. Results indicate that concentrated sweetened cream is at least equal to and possibly superior to other sources of milk fat in this major product.

M. Removal of radionuclides from milk.

Research on the removal of fallout from food, especially milk, continues to be a popular subject with public and political overtones. The utilization research program on the removal of strontium-90 from milk is a joint undertaking of the Atomic Energy Commission, Public Health Service and Agricultural Research Service. A successful procedure has been developed. Milk is acidified to convert all the strontium to a form which will be adsorbed on a cationic exchange resin; the added acid is finally neutralized to return the treated milk to its original pH. A portion of the dairy industry is already acquainted with the ion exchange process through manufacture of low sodium milk on a limited scale. The acidification and neutralization steps are not desirable; further intensive research is now in progress to achieve the same result without them. Cost of the process is being further reduced by additional refinements in techniques. Other methods have been proposed for the removal of strontium-90 from milk. In one of these milk is treated with calcium phosphate which is later removed by filtration or centrifugation; however, drastic changes in milk composition accompany the removal under all conditions so far tried. In addition, the necessity to use one pound of calcium phosphate for each pound of milk solids to achieve effective removal indicates that the seeming simplicity of the process does not necessarily make it less expensive than ion exchange. The Chemical Engineering Division of the Polytechnic Institute of Brooklyn has demonstrated in the Beltsville laboratories that strontium-90 can be effectively removed with an electrodialytic technique. The Civil Defense Division of the Department of Defense has given out a contract to a commercial concern to further develop this process which is based on a plastic membrane permeable to metal ions.

The Public Health Service has initiated nutritional and sanitary studies to gather information on any effects that the ion exchange removal process may have on milk. Two further developments are planned for fiscal 1963 by the Atomic Energy Commission, Public Health Service and Agricultural Research Service in the pilot plant at Beltsville. Glass columns will be supplemented with stainless steel ion exchange columns so that tests can be run under pressure;

equipment for automation of the process will be installed. Funds have been requested for installation of a 100,000 pound per day plant in industrial surroundings.

One of the important questions from the public and the dairy industry is how soon can milk plants install the equipment. A vital factor in this decision is beyond the responsibility of Utilization Research; the government agencies responsible for the safety of food must first decide when treatment is necessary; there is no indication that removal of strontium-90 will be required in the foreseeable future as a result of testing atomic weapons.

N. New drying technique for liquid foods.

A new technique for drying foods was developed by injecting an inert gas under pressure into concentrated cheese whey between the pump and the spray nozzle on a conventional milk dryer. Outstanding success with this product suggested possible extension to other dairy products and foods. A very promising field is dry whole milk; a product with excellent properties when freshly prepared is obtained. There is an increase in dryer capacity of 20 to 30%.

At least one manufacturer of nonfat dry milk has made commercial application of this foam spray drying principle, producing as much as 20,000 pounds of powder per day; he is installing additional equipment. Planned adoption of this technique for nonfat milk and other products is reported, including cultured sour cream and blue cheese in the dairy field. Interest is evident for possible application to eggs and citrus juices.

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OF USDA AND COOPERATIVE RESEARCH

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III. MARKETING RESEARCH

DAIRY PRODUCTS - MARKET QUALITY
Market Quality Research Division, AMS

Problem. Modern marketing practices in the dairy industry have intensified the problems of detecting inferior lots of milk and of increasing the storage life of dairy products. Several kinds of stored-product insects and mites damage or contaminate dairy products and cause extensive losses, principally in nonfat dry milk and cheese. The losses are important not only to the dairy industry but also to the Department in connection with its price support and storage program. To maintain quality of these products in marketing channels, research is urgently needed on the factors influencing keeping quality, and on the development of safe and effective procedures for controlling and/or preventing infestation in warehouse storage, and during transportation by rail, as well as by packaging to provide better protection for nonfat dry milk against infestation. New and improved objective quality tests are also needed for bulk milk and other products. A related problem is the occasional presence of antibiotic and pesticide residues for which improved detection methods are needed.

USDA PROGRAM

There is a continuing program of basic and applied research aimed at developing new and improved methods for assessing the important quality factors in a variety of dairy products. Work is being done at Beltsville, Maryland, and a 2-year contract with the University of California, Davis, California, on protein estimation by dye-binding methods. The Federal scientific effort devoted to research in this area totals approximately 1.0 professional man-years.

A contract with the University of Helsinki, Finland, provides for study of the types of bacteria responsible for the deterioration of market milk. Its duration is 2 years, 1960-1962, and involves P. L. 480 funds with a \$32,462 equivalent in Finmarks.

Also, there is a long-term program involving entomologists and chemists engaged in basic and applied research on the prevention of insect infestation and contamination of dairy products in the marketing channels. Cooperative work with the Wisconsin Agricultural Experiment Station, the Commodity Credit Corporation, and industry groups are included. In addition to work specifically aimed

at insects attacking dairy products, done at Madison, Wisconsin, studies applicable to other insects as well, are conducted at Savannah, Georgia, and are reported in Area 13 "Insect Control in Marketing Channels."

The Federal scientific effort in the insect studies totals 2.5 professional man-years divided as follows: Basic biology and ecology 0.5; insecticide evaluation 0.9; insecticide residues 0.4; insect resistant packages 0.4; and program leadership 0.3.

A research project concerned with developing tests for the sanitary condition of nonfat dry milk was completed.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 10.3 professional man-years divided among subheadings as follows: Objective measurement and evaluation of quality, 5.9; quality maintenance in handling and packaging, 3.0; quality maintenance in storage and transportation, 1.3; insect control, 0.1. Work on objective measurement and evaluation of quality includes sensitivity and accuracy of methods for detecting inhibitory substances in market milk; foreign flavors in dairy products and their identification; composition, physical, chemical and microbiological changes in cottage cheese; physical and chemical investigations on chocolate milk; organoleptic evaluation of ice cream mixes of varying composition; procedures for quality control; and lipase action in market milk. Handling and packaging include research concerning the influence of distribution methods on flavor, composition, and bacteriological conditions of cottage cheese; microbiological and enzymatic changes in fluid milk; microbiological studies on bulk handling of milk; determination of normal freezing point and the incidence of antibiotics in market milk; influence of fluorescent light on milk stored in various containers; and the influence of ice cream packaging materials on quality of ice cream. Storage and transportation research include chemical and bacteriological changes that take place during the bulk storage of milk, lipase activity, and characterization of microorganisms responsible for spoilage. Insect control research is on means to control mites and other insects that infest cheese and dry milk solids that are held in storage for extended periods.

Industry and other organizations conduct research on pesticide and antibiotic residues, microbiological problems related to market quality, and instrumentation. Estimated annual expenditures are equivalent to approximately 20 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Pesticide Residues. Work was continued on improved methods of detection of chlorinated insecticide in dairy products with emphasis on development of one-step chromatographic cleanup procedures which can be used prior to detection and semiquantitative estimation of the insecticides by paper chromatography. An effective and broadly applicable procedure for this purpose was developed using florisil. This provides a relatively simple and sensitive screening procedure for detecting chlorinated insecticide residues in dairy products. A second chromatographic technique using decolorizing carbon was also developed. This was slightly less effective than florisil with most insecticides but it works in some cases where no other chromatographic procedure is known. These chromatographic techniques should be of general value to analysts in the pesticide residue field because no satisfactory chromatographic cleanup techniques were previously available for many of the insecticides studied.

(MQ 3-11)

2. Protein Content. The work on protein estimation by dye-binding methods is being carried out under contract with the University of California. The amido black procedure was selected for use in this study. Optimum conditions for this procedure have been selected and data have been obtained from 574 milk samples. Preliminary examination of results indicates good agreement between dry-binding and Kjeldahl procedures for protein. Statistical analyses have not been completed.

(MQ 3-14)

3. Microbiological Studies. The final report on the study of the direct microscopic count (DMC) carried out under contract with Iowa State University was received. The results showed the effects of heating on direct microscopic count using two methylene blue stains at various stages in the manufacture of nonfat dry milk (using two methylene blue stains). Decreases in count from raw to the dry milk occurred, particularly with rod forms of bacteria. Fair

correlation between DMC's of raw and dry milk was obtained. Staining methods were studied, compared, and some recommendations for improving the techniques were made.

(BS 3-61)

The P. L. 480 contract with the University of Helsinki has been concerned with the activities of microorganisms causing spoilage of market milk. Pseudomonads were implicated as the type of organism chiefly responsible for spoilage at refrigerated temperatures. Pure cultures of pseudomonads did not produce the spoilage observed in actual market milk. Commercial samples of poor keeping quality always contained two or more strains of pseudomonads showing that milk spoilage may result from synergistic action of several kinds of bacteria. Progress has been made on development of a "key" method for identification of bacteria isolated from market milk. It was found that so-called "restoration" of heat-treated bacteria was more apparent than real. Supposedly homogeneous cultures of bacteria really consisted of two distinct populations, one of which was more heat resistant and also more fastidious in its nutritional requirements. After heating, the more heat resistant cells will multiply on suitable media and partially revert to the other type, thus giving the appearance of "restoration" of heat injured bacteria.

(E8-AMS-2(a))

B. Prevention of insect infestation

1. Basic Biology and Ecology. Preliminary studies were conducted to explore the sex attractancy of three species of dermestid beetles that are serious pests in dry-milk processing plants, as well as when the product is in transit or storage. Using a technique developed at the Madison, Wisconsin, laboratory specifically for this study, the existence of a natural chemical sex attractant in Trogoderma glabrum, T. inclusum, and the black carpet beetle was demonstrated. Further studies are continuing with the objective in mind of potential utilization of the attractant for detecting and/or controlling these insects.

(MQ 1-4)

2. Insecticide Evaluation. A proportionate share of the program at Savannah, Georgia, has been charged to this area although much of the work is directly applicable. It is not feasible to report only certain portions here, or to include all the information under each of the several appropriate commodity areas. Therefore, the entire report is included in Area 13.

Studies at Madison, Wisconsin, revealed that malathion, which is currently recommended as a residual spray for dermestid beetle control in dry-milk processing plants and storage areas, is almost instantly detoxified by concrete, a common surface in such locations, and by latex paint commonly used on wall surfaces in the processing plants. It was found that an application of certain traffic marking paints or silicone water proofing treatments prior to the insecticide treatment prevented this detoxification. The search continued for more effective residual sprays. Bayer 29493 was found to be more toxic than malathion on masonite against Trogoderma glabrum but less effective against T. inclusum. It was effective for a time after application to concrete but did not retain toxicity upon aging.

(MQ 1-4)

An article by F. O. Marzke entitled, "Food preference and forced feeding studies with T. inclusum and the black carpet beetle as pests of the dry milk industry," has been submitted to the Journal of Economic Entomology and publication is anticipated in February 1963.

(MQ 1-4)

Synergized pyrethrum continues to be the most effective residual treatment against cheese mites. It appears also to involve a minimum hazard of residues, off-odors, or off-flavors in cheese. Naled, Dimite, dinitrocyclohexylphenol, and chlorobenzilate were promising in preliminary laboratory evaluations but did not hold up for any extended period under more practical testing. DDVP caused no off-flavor in cheese exposed to repeated applications, but later tests indicated it may not be as toxic to mites as suggested by results of preliminary tests.

(BS 1-67)

A special test cage was devised for exposing mites to fumigants. The mites are tiny, fragile, and difficult to manage under experimental conditions. The new type of cage permits observation of the mites and prevents contamination by stray mites during the post-exposure holding period. All mites exposed for 24 hours to methyl bromide at the rate of 1 pound per 1,000 cubit feet were knocked down or dead when the temperature was 35° F. At temperatures of 45°, 55°, and 65° the mites were all dead.

(MQ 1-6)

3. Insecticide Residue Analysis. As with insecticide evaluation, the cross-commodity residue analysis work at Savannah, Georgia, is reported in Area 13.

4. Insect-resistant Packaging. As with insecticide evaluation and residue analysis, the cross-commodity packaging work at Savannah, Georgia, is reported in Area 13.

Several kinds of multiwall paper bags with 3-mil polyethylene inner liners were tested at Madison to evaluate their resistance to invasion and penetration by insects that commonly infest nonfat dry milk packages. Bags with stitching through the tape closure were most easily invaded. Smooth flat bags with a polyethylene-laminated, heat-sealed tape over stitching were not invaded during a 12-month exposure to insects. Residues were detected in dry milk stored 6 months in bags with the outer ply treated with synergized pyrethrum or methoxychlor. Such residues of synergized pyrethrum are covered by a temporary Food and Drug tolerance but there is none for methoxychlor.

(MQ 1-13)

PUBLICATIONS REPORTING RESULTS OF USDA AND
COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Moats, William A. 1961. Chemical changes in bacteria heated in milk and other media as related to loss of stainability, Journal of Dairy Science, XLIV(8): 1431-1439.

Moats, William A. 1962. One-step chromatographic cleanup of chlorinated hydrocarbon pesticide residues in butterfat. I. Chromatography on silic acid, Journal of the Assoc. Off. Agr. Chem., 45: 355-358.

Moats, William A. 1962. Cleanup of some chlorinated insecticides in butterfat by chromatography on florisil, Abstract, American Chemical Society.

Prevention of Insect Infestation

Stored-Product Insects Branch and Wisconsin Agricultural Experiment Station. 1962. Insect prevention and control in plants processing dry milk, USDA AMS-302 Revised, May 1962, 12 pages.

DAIRY PRODUCTS - MARKETING FACILITIES,
EQUIPMENT AND METHODS
Transportation and Facilities Research Division, AMS

Problem. A survey of market milk and ice cream plants throughout the country, by the University of Illinois in 1958, shows that the equipment, work methods, and facilities of many of these plants are obsolete and the production per man-hour employed relatively low. Moreover, many of these plants use excessive labor in maintaining records and preparing reports. A major factor contributing to this obsolescence is the development during the last few years of new types of equipment which can be brought under automatic control. Because of the investment required and the uncertainties of the returns they would obtain, plant operators have been reluctant to shift to automated equipment on a piecemeal basis. They also have been reluctant to build new plants because of a lack of guidelines and criteria on automated plants. However, studies indicate that it is possible in fully-automated plants to increase the productivity of labor 100 percent or more, to improve the qualities of the finished products, and to develop better management-employee relations. Engineering layouts and operating criteria therefore are needed for automated plants to provide guides to plant operators in making the shift from their present equipment and facilities. Most dairy plants lack the technological and engineering skills necessary to plan and develop suitable plant layouts and designs, or to select the types of equipment needed and the controls necessary for full automation. Automated equipment and processes for some types of dairy plants still largely are lacking or are nonexistent. Therefore, engineering research also is needed to develop equipment and processes for automating these plants in order to increase labor productivity and improve product quality.

USDA PROGRAM

The Department has a continuing long-term research program involving industrial engineers, mechanical engineers, and dairy technologists engaged in both basic and applied research to develop new and improved work methods, equipment, and plant layouts for dairy plant operators.

Current research, conducted under contract at DeLand, Florida, covers the development of layouts and operating criteria, based on current technology, for automated dairy product plants. It features the use of remotely-operated valves, electronic-controlled devices, and highly mechanized equipment. The six types of dairy plants covered are: (1) Special purpose fluid milk plants; (2) fluid milk plants that process byproducts; (3) ice cream and ice cream novelty plants; (4) cottage cheese and cultured milk product plants; (5) cheddar cheese plants; and (6) sweet cream butter and dried nonfat milk plants.

The Federal effort devoted to research in this area is 0.9 professional man-year per year: 0.5 man-year for contract work and 0.4 man-year for program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Equipment Manufacturers. It is estimated that roughly 175 different firms design, manufacture, and sell dairy plant equipment. Of this number, three relatively large firms manufacture fairly complete lines of equipment for commercial operations. The remaining manufacturers usually specialize on one or more items or lines of equipment. All of these firms conduct research and development work, usually with their own staff members, in order to stay in business. In this research the emphasis is on new or improved items of equipment which can be patented and for which there is thought to be a ready market outlet. A number of the larger firms maintain research and development divisions and employ full-time research engineers. Others use sales engineers on a part-time basis for research and development work. Occasionally this work is done under contract and in collaboration with one of the larger manufacturers of dairy products. Estimated annual expenditures are equivalent to approximately 350 man-years.

Manufacturers of Dairy Products. Although a number of manufacturers of dairy products conduct a limited amount of research in the engineering and technology fields, about six of the larger firms maintain engineering research staffs to develop improved plant layouts, conduct studies directed toward increasing plant efficiency, set up time standard for various operations, and do equipment development work. Estimated annual expenditures are equivalent to approximately 100 professional man-years.

REPORT OF PROGRESS OF USDA AND COOPERATIVE PROGRAMS

A. Economic-Engineering Studies of Dairy Plant Layouts, Work Methods, and Record Systems

At Lafayette, Ind., three studies, conducted in cooperation with the Purdue University Agricultural Experiment Station, were completed in 1961, except as noted below.

1. Improved Work Methods and Layouts for Ice Cream Plants. The study shows that improved work methods and plant layouts can reduce costs for a typical plant manufacturing 150,000 gallons of ice cream annually by \$23.69 per 1,000 gallons or about \$3,600 annually. This reduction

is based on a plant manufacturing 5 flavors of ice cream and packaging in 7 container sizes. All reductions in costs by improved methods are in equipment costs.

Labor costs are higher. This situation stems from the fact that, for a plant of this size, manual methods are more economical than methods requiring relatively high-cost equipment. The manuscript contains a suggested layout for an ice cream plant manufacturing 150,000 gallons annually. It also shows how the plant could be expanded to manufacture 300,000 gallons annually. This study has been completed and a report published.

2. Improved Records and Reports for Fluid Milk Plants. This study has established for single-firm milk bottling plants the basic information needed for rational management and operation decisions. Five plants were studied in considerable detail, and several others in less detail, in order to establish appropriate information needs, feasible records, and the most usable reports covering such information. A manuscript covering the findings of this study is being prepared for publication by the Purdue University Station.

3. A procedure for Planning the Most Efficient Use of Dairy Manufacturing Plant Resources, Including Labor and Facilities. This study has used simulation techniques to establish the most economical labor schedules and raw milk purchase plans for a cheese operation. Man-machine requirements were established as a part of the necessary data. The basic contribution of this study has been to help establish the feasibility for using simulation techniques and management planning of such a processing facility. A manuscript covering the findings is being prepared for publication by the Purdue University Station.

B. Layouts and Operating Criteria for Automated Dairy Product Plants

At DeLand, Fla., four studies conducted under a research contract covered:

1. Layouts and Operating Criteria for a Special Purpose Milk Plant (Market Milk and Half-and-half). A manuscript, for a Department publication, covering layouts and operating criteria for special purpose milk plants was completed. The report shows that a special purpose automated milk plant handling 35,000 gallons of milk weekly, having an improved layout, can reduce its labor cost \$26,000 annually when compared with a nonautomated plant having a typical layout; and that a plant handling 105,000 gallons weekly can reduce its costs \$39,000 annually.

2. Layouts and Operating Criteria for a Multipurpose Milk Plant (Market Milk, Half-and-half, Coffee Cream, Buttermilk and Chocolate Drink). A manuscript, for a Department publication, covering layouts

and operating criteria for automated and highly mechanized multi-purpose plants was completed. The report shows that a multipurpose automated milk plant handling 35,000 gallons weekly, having an improved layout, can reduce its labor cost \$32,500 when compared with a non-automated plant having a typical layout; a plant handling 105,000 gallons weekly can reduce its costs \$58,500 annually.

3. Layouts and Operating Criteria for Automated Ice Cream Plants. Although the contractor has submitted his report on this study, its review has not progressed to the stage where significant findings can be summarized.

4. Layout and Operating Criteria for Automated Plants Manufacturing Cottage Cheese and Cream Cheese, and Cultured Milk and Cream. Although the contractor has submitted his report on this study, its review has not progressed to a stage where significant findings can be summarized.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Economic-Engineering Studies of Dairy Plant Layouts, Work Methods, and Record Systems

Taylor, James C., October 1961. Ice Cream Manufacturing Plants in the Midwest - Methods, Equipment, and Layout. Marketing Research Report No. 477.

CONSUMER PACKAGES AND SHIPPING CONTAINERS
Transportation and Facilities Research Division, AMS

Problem. Many of our conventional consumer packages and shipping containers (1) are relatively expensive; (2) require a substantial amount of labor to assemble, fill, and close; (3) are comparatively heavy, hence costly to transport and difficult to handle; (4) are unsuitable for storage; (5) do not adequately protect their contents from damage; (6) fail to make an attractive retail display to stimulate impulse buying; and (7) lose potential sales because of poor visibility provided for contents. Furthermore, the marketing of agricultural products has been subjected to rising costs of materials, labor, and transportation and to a revolutionary change in the fresh food distribution system at the retail level--the emergence and takeover by the supermarkets. Supermarkets are dependent on a high level of self service but self service breaks down without a price-marked, unitized product. This has increased the need for improved packages which provide consumers with perishable agricultural products in better condition than those often found in bulk displays. Cheaper, more attractive, and more protective packaging, which cuts transit and handling damage losses, should stem the decline in consumption of many fresh commodities and contribute to increased returns to farmers.

USDA PROGRAM

This is a continuing program of applied research involving marketing specialists, industrial engineers, and agricultural economists to (1) develop new or improved consumer packages, master containers, packing materials, and shipping containers for agricultural products; (2) evaluate them from the standpoint of costs of materials and direct labor to pack, and their ability to reduce product damage and to increase its salability; (3) determine at which point in the marketing system packaging can be done most effectively; (4) improve the efficiency of packaging methods to cut costs; (5) and investigate the needs for and benefits of container standardization and simplification. Current packaging and container research is concentrated for the most part in six commodity areas, each with differing needs: Deciduous fruits, citrus fruits, vegetables, potatoes, poultry, and dairy products. The program is carried on in co-operation with experiment stations in California, Oregon, Washington, New York, South Carolina, Arkansas, Delaware, and Florida; at branch field stations in Orlando, Fla., Fresno, Calif., and Yakima, Wash., in other main producing areas, and in the principal terminal markets.

This program involves 9.4 professional Federal man-years annually; (a) Deciduous fruits, 3.3; (b) citrus fruits, 0.6; (c) vegetables, 2.3; (d) potatoes, 0.5; (e) dairy products, 0.2; (f) poultry, 1.5; (g) cotton, 0.3; (h) other, 0.2; and (i) program leadership, 0.5.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Manufacturers and Suppliers. The 1960 Directory of Industrial Research Laboratories in the United States lists 75 firms engaged in packaging research and 37 doing research on various types of containers, such as boxes and bags. More than 30 of our recent cooperators are included in the listings. The directory indicates that their laboratories are staffed by from 20 to almost 400 professional workers each. However, much of their research centers on formulation of basic materials and methods of conversion to end-product components of packages and containers.

Furthermore, most new packages and containers are aimed at penetration of non-agricultural markets. It is estimated that between 100 and 150 researchers of professional status are engaged directly in the development of consumer packages, master containers, bulk shipping containers, and packaging materials for possible use by growers, packers, shippers, and distributors of agricultural products. This work does not duplicate but is correlative with USDA research which evaluates new packages and containers and is primarily concerned with their ability to satisfy the requirements of specific agricultural commodities.

Dairy Products

Three types of new disposable 5-gallon containers for milk served from dispenser units were evaluated in comparison with the conventional 5-gallon cans. All the new containers were basically the same, a polyethylene bag insert in a semi-rigid fiberboard box or cylinder. Each new container was studied in two plants--a total of six. Although the studies have not been completed, preliminary indications are that costs of the new containers and the labor to fill and handle them in the plant are very slightly higher than for the re-usable cans. However, certain advantages, including superior sanitation features and elimination of the washing operation, may outweigh the minor differences in costs.

IV. ECONOMIC RESEARCH

ECONOMICS OF MARKETING
Marketing Economics Division, ERS

Problem: Within most agricultural processing industries rapid and drastic changes in their market organization and practices are occurring. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economies of scale and efficiencies possible in the marketing of farm products. A significant aspect of the problem in marketing is that this type of information must be obtained from firms engaged in business -- in contrast with other types of research where the problem can be transferred to a laboratory, experimental plot, or other simulated situation. Consequently, it requires the cooperation of people engaged in making their living and assisting with marketing economic research on the side where their own merchandise, facilities, and opportunity for profit and loss to themselves is involved. Another aspect of the problem is that only large firms can afford this type of research, consequently, public research has been requested for the many smaller firms. Furthermore, there is the need for comparison and analysis where even large firms do not have access to the plants and records of competitors.

Also, marketing research is increasingly directed toward evaluating present and prospective programs pertaining to agriculture such as the Food Stamp Program and Federal grading activities and to the changing structure of market industries. Changes in programs or market structure may influence the bargaining power of farmers. Marketing research also is being directed to the economics of transportation and storage activities of both private firms and government. Increasing attention is being given to the longer-term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Area Development Program and in assessing prospective inter-regional shifts in the areas of production and marketing for specific products.

USDA PROGRAM

The Department has a continuing program to determine the reasons for the changes that are taking place in marketing so that ways can be found to increase the efficiency of the marketing system and make it more responsive to changing public needs. Because more than 60% of the consumer's dollar spent for dairy products goes for marketing activities, this work encompasses a wide range of subject-matter.

It covers all economic aspects of marketing from the time the products leave the farm until they are purchased by ultimate consumers. Much marketing research is functional in nature and could apply to a number of commodities. To the extent the research effort devoted to dairy products can be distinguished, it is shown in terms of professional man-years in parentheses at the end of the following subareas:

A. Distribution Programs.

This continuing program involves agricultural economists, alone or with the cooperation of human nutritionists and program specialists, engaged in the development of basic and applied information contributing to the development and operation of effective public food distribution programs. During 1961-1962 approximately 1 of every 6 persons in the United States participated in food distribution programs of the U. S. Department of Agriculture. This participation could have occurred through Direct Distribution, Food Stamp, National School Lunch and Special Milk Programs. This research program is designed to measure program effectiveness and the potential impact of present or alternative programs upon markets for agricultural commodities, and on prices and farm income, so that guidelines can be provided for administrators and others concerned with policy determination and operational efficiency. (0.1)

B. Market Potentials for New Products and Uses.

This work is directed at the commercial feasibility and market potentials of new or improved dairy products, appraisal of their impact on present markets, and of the economic and technical requirements of end-uses. Such evaluation will provide a sound economic base for decisions on commercial development as well as information to guide further utilization research by physical scientists. (1.7)

C. Merchandising and Promotion.

This is research to evaluate promotional programs to determine: (1) responsiveness to advertising and promotional activities and to identify characteristics of products that are responsive saleswise to promotion; (2) relative effectiveness of different promotional techniques or approaches when employed alone or in combination; (3) sales response-promotional investment relationship for selected products; and (4) organizational structure and procedures for optimum control, coordination and effective conduct of program. Another phase of the research program involves analysis of movement and availability data at retail and wholesale levels and consumer purchase data by family characteristics including regions, rural and urban areas. This research delineates markets and provides producer groups information on movement and market profiles for specific products in planning and executing marketing programs.

Research is conducted to determine the influence on sales and consumer demand of merchandising practices and pricing policies characterising the marketing of specific commodities at the retail and wholesale levels of distribution. Evaluations are planned so that findings contribute to general principles and standards of performance relating to such factors as methods, type, location and size of displays; type, kind, color and size of package; variety and quality of products; and pricing techniques. Another basic area of research is designed to increase the efficiency of management through improvements in accounting procedures, inventory control, ordering, space allocation, and functional coordination between wholesalers and retailers and thereby reduce costs associated with these items in the distribution of farm commodities. (1.3)

D. Economics of Product Quality.

This program of basic and applied research on the economics of product quality includes study of the problems of seven different commodity groups, including milk. Work on all commodities is carried on at Washington. In addition, work on the protein content of milk is being directed at Davis, California, under contract with the California Agricultural Experiment Station. An early contribution made by government to improve the economic well-being of farmers was the establishment of standards for farm products. This assured the dependability of quality and strengthened farmers' competitive position. Knowledge of the impact of government grades on market practices and market structure provides a basis for answers to questions of public policy related to government grading programs. (1.3)

E. Marketing Costs, Margins, and Efficiency.

This is a continuing long-term program. In nearly all studies, close cooperation is maintained with industry and trade groups and with individual private firms that provide essential data from their records and make their plant facilities available for observation in the conduct of various marketing tests. Much of the research is problem-solving in nature with a limited amount of research devoted to development of improved research techniques. Although much of the research is conducted by personnel in Washington, D. C., a considerable part of the work is done by USDA professional staff located in the States.

Several projects are underway but no progress is reported because they were initiated recently in the reporting period. Those pertaining to dairy are: (1) analysis of marketing margins and practices for fluid milk in regulated markets, (2) a study of capacity and flexibility of facilities in milk manufacturing plants to help plant operators in making decisions relative to type and capacity of facilities to secure the degree of flexibility of facilities needed, and the costs and bene-

fits of flexibility and diversification of operations, and (3) continuing collection and analysis of marketing margins, practices, and trends for fats and oils in the principal and products of these industries. (3.8)

F. Market Structure, Practices, and Competition

This area of work is devoted to analyzing the competitive positions of commodities; producing areas and farms; and the changes within marketing firms in response to shifts in location and technology of production; changes in demand and location of population; changes in transportation, processing, and marketing methods, development of new products; and changes in agricultural programs.

Dairy marketing research emphasizes change -- changes in the structure of markets and in marketing practices and the impact of these changes on marketing firms, producers, and consumers. The impacts of the growth of "drive-in dairies" on handlers of other types and on producers and consumers are being studied. Research into the nature and causes of retail milk price wars in city markets indicate impacts of such wars upon consumer prices, producer incomes, and the margins and comparative relationships among handlers. The flexibility of dairy manufacturing plants is shifting among products and has resulted from and contributed to many changes, including (1) a shift from farm-separated cream to wholesale milk sales by farmers, (2) the improved quality of raw milk supply, (3) changes in the relative importance of different dairy products, (4) improved transportation facilities which have extended supply areas and the market for finished products, and (5) larger and fewer plants with more progressive management. Pooling in fluid milk markets is being analyzed in relation to change in supply and demand conditions to determine the effect of various ways of pooling on producers and plants, the structure of the market, and the relation of price to supply, and to analyze ways in which pooling might adjust to changing market conditions. (5.0)

G. Information, Outlook, and Rural Development.

This program is designed to assist the Department in improving the usefulness of its output of marketing information through studies (1) to evaluate the uses made by both private and public users of information; (2) to determine the nature of the primary needs of these users for information; (3) to develop improved means of collecting data, making estimates, and reporting essential information; and (4) to evaluate impacts that information services have on decision making by farmers, marketing firms, and public and semi-public agencies. This is a case where the functional nature of the work does not permit distinguishing the man-years of effort specifically for dairy, however, one example of the work is the measurement of the farm-retail price spread and determination of the farmer's share of the retail cost of dairy products, which is part of the study involving many agricultural commodities.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

A brief but overall treatment of dairy research by States and industry is included in the "Introduction," beginning on page v. To the extent information was available the work by States and industry is reported under the following subareas with professional man-years shown in parentheses at the end of each section:

A. Distribution Programs.

In 1961 State Experiment Stations reported work on analyzing phases of the Special Milk Program in Illinois, Minnesota, Alabama, and Maryland. (1.4)

B. Market Potentials for New Products and Uses.

State Experiment Stations in 1961 reported 0.6 professional man-years devoted to dairy products. Workers in Indiana, Michigan and Pennsylvania were engaged in the analysis and handling of milk and milk products to develop greater efficiency in the processing and distribution of dairy products to meet new and present needs, and thereby increase consumption.(0.6)

Industry provides assistance through the American Dairy Association by sponsoring research on the development of new products and in the trial and evaluation of them in the early stages of commercial introduction. Also, some of this work is in cooperation with the USDA.

C. Merchandising and Promotion.

Research on merchandising and promotion on dairy products was conducted in most areas of the Nation in 1961. (3.7)

D. Market Structure, Practices, and Competition.

The State Experiment Stations in all regions are engaged in research on market structure and practices as they affect the marketing of local dairy products. In regional project NCM-26, Changing Market Structure and Organization of the Midwest Dairy Industry, the North Central States are evaluating changes in the market structure and organization in relationship to changes in the commercial use of milk, production areas and practices and processing plant efficiency.

Effects on the income of producers, and on the public interest is also appraised. The Northeastern States are studying the effect of bulk assembling of milk, new methods of packaging, pasteurization methods and regulations, and various technological developments on the market structure for milk. In addition, the effect of changing economic conditions, farm technology, and quotas on the volume and pattern of milk production is being investigated. The relationship of these

factors to surplus milk and to the dairy manufacturing industry will be made explicit. Southern States are coordinating their research on institutional forces affecting the Grade A milk industry, the supply of milk for manufacturing, fluid milk movement to market areas, and plant organization and location under SM-10, Establishing Guides for Efficient Organization of the Dairy Industry under Changing Conditions in the South. Western States are studying adjustments in type and capacity of plants in manufacturing, the impact of changes upon amount of milk available, changes in the nature and type of competition, and other aspects of market structure under WM-46, Effects of Changes in Marketing Methods and Systems on Milk Marketing in the Western Region.

The Alaska and Wisconsin stations are studying the competitive position of their dairy industries relative to other regions. In the former State, emphasis is on ability to compete with shipped-in and recombined products, while the latter is evaluating possibilities for widening market outlets in other regions.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Distribution Programs.

Evaluation of Special Milk Program. No work has been undertaken during the reporting period other than through the milk services phase of the market for food in schools project. This involved mailing questionnaires concerning school food services to a representative sample (5 percent) of about 5,000 public and 1,000 private elementary and secondary schools.

B. Market Potentials for New Products and Uses.

Market Potentials for Low-fat (Two percent) Milk. Changes in consumers' purchasing and consumption habits combined with competition from other products were significant factors behind a 10 percent drop in the per capita consumption of fluid milk and cream between 1950-60. In an attempt to increase fluid milk consumption the industry has begun marketing a low fat milk. This product, commonly referred to as "2 percent milk," contains approximately 2 percent butterfat with or without additional non-fat solids and/or vitamins.

All segments of the dairy industry as well as the Federal Government, because of its dairy support program, have a vital interest in any product whose sale may increase the overall consumption of fluid milk. Therefore, this study is being made to determine the market potential for this low fat product, and measure on a continuing basis its sales impact on other fluid milk products in order to provide objective information heretofore not available to the various segments of the dairy industry on the effect of "2 percent milk" on total milk consumption.

Federal Milk Order Market Administrators have furnished information by mail concerning the availability of sales data, product composition, brand names and initial date of sale of low-fat (2 percent milk) in their areas. Analysis of the data shows the product is currently sold in 71 of the 81 order markets. This material is being used for the preliminary selection of cities in which surveys of consumers and fluid milk processors will be conducted. Beginning in July 1962, market administrators will report sales data for the "2 percent" product as a separate item on their monthly product reports.

C. Merchandising and Promotion.

It is estimated that restaurants and other public eating places account for 20 to 25 percent of total food expenditures. A survey of merchandising and promotional practices employed by these establishments for milk and other products was conducted under contract to provide dairy, other agricultural groups and restaurant operators with pertinent information on current practices employed by these firms as related to sales volume and net returns.

The results showed that milk was carried by the majority of establishments only as a service to customers. Milk was not considered to be a source of income, however, management consistently under-estimated the gross margins earned per serving. Milk was offered on menus most often as a separate item, and very rarely as a choice of beverages with a meal at no extra charge. Approximately one-fourth of those interviewed in Hartford indicated that they participated in special promotional programs (such as June Dairy Month) for dairy products. However, only 3 percent of those interviewed in Indianapolis reported participating. The reason most frequently given for not participating was that they did not know about the program or were not asked to participate. Point-of-purchase materials for dairy products were observed in about 20 percent of the establishments. The materials most frequently used were window signs and decals encouraging the purchase of ice cream.

Butter was used as a spread by 90 percent of the firms in Hartford, but by only 40 percent in Indianapolis. The average quantity used per week for table use was 13 pounds in Hartford and 14 pounds in Indianapolis. The average quantity used per establishment relative to other spreads in both cities increased with the annual sales volume.

About one-half of the respondents interviewed indicated a desire for menu suggestions.

D. Economics of Product Quality.

1. Variability of Butterfat Tests. The establishment of accurate butterfat tests for milk producers will be greatly facilitated by a statistical analysis of the inherent day-to-day variability in the butterfat content of the individual producer's milk and the accuracy to be expected of various sampling and testing procedures. One report dealing with the effect which selected factors have on the accuracy of the individual producer's butterfat tests has been published. A second report is being readied for publication. This report compares results of individual producer's tests made by using (1) composite sample tests, (2) daily fresh sample tests, and (3) varying numbers of random or stratified fresh sample tests.

2. Quality-Price Relationships for Butter. The relationships of prices and grades of butter at the retail level are not consistent.

Two sets of butter samples purchased in Wilmington, Delaware, stores were graded. About two-thirds of the butter sold in Wilmington stores was grade A or AA. The average quality was higher in chainstores and large self-service independents than in other types of stores. On the average, prices were not related to grade level. Rather, prices tended to reflect the amount and type of service given to consumers. Considerable variation in grades occurred within brands of butter, without corresponding variations in price. Flavor characteristics varied within brands, without a consistent relationship to price.

3. Methods of Determining Protein and Solid-Not-Fat as a Basis for Purchasing Milk. This work is to: (a) Select the dye-binding method of measuring protein content of milk that is best adapted for use in commercial milk plants; and (b) determine day-to-day variability in protein and solids-not-fat content of herd milk as a basis for sampling routines for producers' milk deliveries. Preliminary work on the amido black procedure has been done including spectral analysis, the effect of pH, dye concentration, equilibrium conditions, time and speed of centrifugation, time of shaking, dilution, accuracy, and precision. The absorption maximum was found to be about 615 mu rather than 675-690 mu as used by the Dutch workers. The contractor is of the opinion that sufficient is known about the dye-binding methods to indicate that amido black is the method of choice and additional work with orange G or buffalo black is unnecessary.

E. Marketing Costs, Margins, and Efficiency.

There is widespread concern and demand for information on the amount of, and trends in, costs and margins for processing and distributing milk. Eight quarterly publications, presenting costs and margins for fluid milk processing and distributing, were issued during the past two years. These include special analyses on (1) sales outlets and

products; (2) personnel costs and labor efficiency; (3) work week, earnings, and rates of pay; and (4) wages, labor output, and unit costs of labor. Retail sales continued to decline as a percentage of total sales. Homogenized milk accounts for an increasing percentage of total sales and low fat items are growing in importance. Personnel costs increased during the 1955-61 period; greater efficiency in the use of labor has been more than offset by increases in wage rates. Most fluid milk plants now operate on a 40-hour week. Output per man-hour is related to rate of pay. In most cases, high productivity occurs in plants which pay high wage rates, indicating that either high wages provide the incentive for use of labor-saving equipment and methods, or that efficient equipment and methods provide a basis for higher wages. Processing costs are inversely related to scale of operations. Multiple-quart containers account for an increasing proportion of the fluid milk business. Over 20 percent of all fluid milk products are consumed away from home; major non-home consumption is in eating places and institutions. For a large sample of milk distributors average net sales receipts averaged \$11.37 per 100 pounds of milk processed in 1961, raw product costs were \$5.97, gross margins were \$5.40, total operating costs were \$4.97, and net margins averaged 43 cents prior to income taxes. Although gross margins in 1961 were about 10 percent higher than in 1955, net margins were a cent a hundred-weight lower. Salaries, wages, and commissions at \$2.67 per 100 pounds of milk processed were nearly 20 percent higher than in 1955. Special analyses from the quarterly reports have been put into one publication which will be issued soon. Comprehensive analyses are planned to cover: (1) Amount and relationships of changes in sales value, costs of raw materials, and the individual elements of operating costs; (2) products handled; (3) sales of homogenized milk (container sizes and sales outlets); (4) growth in size of milk distributors' plants; (5) seasonal variations in the fluid milk business; (6) selling prices (both nominal and realized); (7) increases in costs and relative costs of retail and wholesale sales; and (8) relative efficiency of glass, paper, and glass-paper operations.

Seasonal variation in supplies of milk cause labor costs in manufacturing milk plants to be higher than if there were less variation. The basic labor policy of the dairy manufacturing plants studied by Purdue University under contract with the Department is one of maintaining the same-sized labor force throughout the year with the addition of seasonal employees during the summer. Under these conditions, only meager reductions in labor costs can be made by leveling out production at the annual average level. Additional savings can be obtained through using equipment near capacity levels throughout the year, i.e., leveling out plant receipts at volumes close to full capacity. A preliminary draft of a report of this study is now being revised for publication.

The dairy industry in the South must adjust to development in production, processing, and distribution of milk as well as to changes in the Southern economy and population. To adjust efficiently and rapidly, the industry needs analyses of the probable factor changes and technological developments to show effects of these changes. Supply and movement data have been collected. A regional report has been written showing by volume the present (1959) movement pattern of Grade A fluid milk by area of origin and area of destination for both producer supplies and product distribution. These data are being analyzed to determine the least-cost movement pattern for producer supplies moving to the processing centers. Using the Reactive Programming technique the distribution data have been analyzed to show the movement patterns which result in equal net prices to processing areas and maximum net revenue to processing areas assuming given processing and distribution costs and demand functions. This analysis shows some shifts in the movement pattern. Producer supplies of Grade A milk and aggregate demand for fluid milk have been projected for various time periods by economic areas within each State. These data are being analyzed to show movement patterns which result in maximum net revenues to areas. These results will provide guidelines to the dairy industry. At least 3 regional reports are planned showing the results of the analysis. Comparisons will be made between the present pattern of milk movement in the South and the movement pattern shown by the least-cost, maximum revenue analysis. Analysis of milk movement under alternative market structures and price relationships will be completed. Economic models will be synthesized based on alternative levels of supply and demand and specified technological developments which will show numbers, location, and size of firms (milk producers and processors) necessary in future time periods for an efficient industry. Also a report will be written describing institutional factors which affect milk movement patterns with implications of such factors considered.

F. Market Structure, Practices, and Competition.

Managers of marketing firms can improve the accuracy of their decisions by giving some thought to the manner in which they reach decisions. This conclusion was reached in studying the way information is used in decision making in the shift from cream to whole milk and the choices between can-bulk methods of handling milk in South Dakota dairy plants.

The analysis demonstrated that decision making was performed primarily by managers of the firms. They were influenced by a wide variety of sources of information. The process of arriving at a decision was viewed differently by the managers and outside observers who had been in contact with them before and after the shifts in procurement. It was not possible after the decision to reconstruct the steps by which the managers shifted from being satisfied with their former method of operation to being convinced that the new method (assembly of whole milk and choice of bulk handling) should be adopted.

A study aimed at an understanding of the causes and consequences of the price wars which occur sporadically in city milk markets shows these price wars may cause insolvencies among milk dealers and losses to the farmers who supply them. They also pose problems of policy for State and Federal agencies concerned with milk marketing and the enforcement of fair trade practices. In more than 20 cases of milk price wars studied, it has been possible to distinguish between the commonly observed "destructive" aspects of price wars, such as breakdowns of orderly marketing and the extreme pressures on small firms and other aspects which play a part in changing conditions of milk marketing. Thus, price cutting which has touched off price wars in some city milk markets has appeared to be incidental to improvements in transportation and refrigeration. Analysis of the drive-in dairy store industry in central California identified the factors and conditions which permit introduction and successful operation of this new type of store. Study indicates that the basic impetus to their development arises from a supply of fluid milk of market grade significantly in excess of the market requirement for such milk plus a guaranteed sales price which limits competition to nonprice considerations. Also, (1) the development of new housing subdivisions, (2) the breakdown of older marketing methods and loyalties and acceptance of new ones as well as (3) a growing consumer awareness of sales prices encouraged introduction of drive-in stores.

In spite of accepted economies of scale in processing by larger plants, small drive-in processors are able to compete by eliminating costly services of delivery. Also, in many cases the operator of a drive-in is willing to accept a residual between his sales returns and operating expenses as adequate return for his labor, capital, risk and other factors regardless of their return in alternative employment.

The movement of bulk milk from outside sources into fluid milk markets is growing and prices of milk are more closely related among markets as a result. Comparison of price maps of dealers' buying prices for fluid milk demonstrated a closer alignment of prices between distant markets and major supply areas during 1960-61 than in either 1953-54 or 1957-58. Buying prices in Eastern markets were generally lower in 1960-61 than in 1957-58.

The setting of prices for Class III milk under the New York-New Jersey Federal and State milk marketing orders must consider the effect of prices on the utilization of milk in that class. Manufacturers in the market varied their output in response to changes in net margins, but that net margins accounted for a relatively small part of the total variation in output. Chief among the factors, other than margins, were difficulties in finding outlets for products which processors might want to produce in larger quantities. Other factors included the geographic scope of processors' sales activities, commitments to producers for supplies of milk and to buyers of the products, multiplicity of health approvals, and pool plant status.

Prices had been generally favorable to manufacturers using Class III milk from the New York-New Jersey pool and had been below competitive levels. An increase in prices would also carry increased risk that not all the Class III milk would be sold. The alternatives are limiting supplies, providing for competitive determination of Class III prices, or of establishing further use classifications.

Technological innovations in the milk market industry and local and regional shifts in the demand for and production of milk are instigating changes in the structure of the industry. Shifts in the source of supply and in the utilization of milk in the Pacific States, and specifically in the Portland-Vancouver market, have been analyzed and the results show the dynamics of milk market structure such as changes in shares of the market held by individual distributors, and the complex interactions among producers, producer organizations, and milk marketing firms. Efficient handling of surpluses in fluid milk markets can contribute to market stability and to increased returns to milk producers. Detailed information as to the character of these surpluses and the types of arrangements used in marketing them in 14 major markets have been analyzed, and budgetary analysis completed of alternative arrangements for disposing of surplus fluid milk in each of three markets. Linear programming analysis was employed to show the practicability of using a large, diversified dairy manufacturing plant as the outlet for the surplus fluid milk from several local markets.

Study of surplus milk problems and handling arrangements brings out that fluid milk dealers use surplus milk they process largely in cottage cheese and ice cream. Milk in excess of that used by bottlers in fluid items and in these products is largely manufactured either by plants that regularly receive milk of manufacturing quality or by standby plants. Increasingly the disposal of this more burdensome type of surplus is being taken over by fluid milk cooperatives. The assumption of greater responsibility by cooperatives and the advent of bulk handling of milk on the farm are facilitating the diversion of this excess directly from farms to manufacturing facilities. This comparatively efficient disposal arrangement is now the dominant one in most large city markets that have the bulk of this excess milk.

Analysis of the mechanics of supply-demand adjusters examines the characteristics of adjuster mechanisms and relates them to the behavior of the adjuster. While it brings out that there is no ideal mechanism, it points up the many problems associated with short-time fluctuations and changes in the seasonal pattern of production inherent in the use of the two-month movers that are most commonly employed.

The methods of pricing and marketing surplus milk; i.e., milk used for other than fluid purposes, have substantial effects on returns to producers and processors.

A study of market structures and practices for cottage cheese and frozen dairy products in relation to pricing surplus milk in fluid milk markets in Kansas, Missouri, and Oklahoma showed how to improve pricing practices for surplus milk. Fluid milk plants in these States use about 10 percent of their surplus butterfat and frozen dairy products. These products account for about 18 percent of total dollar sales. More than 80 percent of all cottage cheese and frozen dairy products are sold to stores, hospitals, etc. Sales in outside markets are important to many plants, particularly to larger plants. The findings indicated that if plants are unable to absorb higher ingredient costs, they might find it difficult to offset higher costs by raising selling prices. Also, many plants may switch to using other lower cost ingredients which are readily available.

Efficient handling of surpluses in fluid milk markets can contribute to market stability and to increased returns to milk producers. After completion of a survey of surplus milk handling problems and arrangements in more than 100 midwestern markets, detailed information was obtained as to the character of these surpluses and types of arrangements used in handling them in 14 major markets. A study of the mechanics of supply-demand adjusters, as devices used to help regulate milk supplies in fluid markets, was completed with publication of a regional report.

Plans were advanced for a study of changes in the organization and structure of the dairy industry, their consequences to the industry and to the general public, and alternative public, industry and firm policies needed in consequence of them.

After extensive planning, arrangements have been completed for special tabulations to be obtained from the Bureau of the Census. These will provide information on market shares of groups of leading companies in each major dairy industry, and on the size of plants operated by each of the various types of organizations in each of those industries. Additional data are being obtained as a byproduct of a United States Department of Agriculture study of flexibility in dairy plant operations. These data will show production, by major products, in plants of differing degrees of specialization; share of output by largest plants, frequency distributions of manufacturing operations by size, by major products groups, relation of size to degree of diversification, etc. Still other information is being obtained from (1) analyses of trends in shares of packaged milk sales in the various Federal order markets made by the group of four largest handlers; (2) determination of the shares of output of each major dairy product in 1954 and 1958 by groups of the largest plants as determined from Census of Manufactures data on employment; (3) reports of the Federal Trade Commission and similar agencies; and (4) State data on numbers, size, ownership, etc. of dairy plants. An outline has been developed for a proposed regional manuscript, tentatively entitled "Changing Organization of the Dairy Marketing Industry of the North Central States."

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CONSUMER PREFERENCE AND QUALITY DISCRIMINATION--
HOUSEHOLD AND INDUSTRIAL
Statistical Reporting Service

Problem. With the increasing complexity of marketing channels and methods, it has become almost impossible for the consumer to express to producers either his pleasure or displeasure with available merchandise. In order to market agricultural products more efficiently, we need to understand existing household, institutional, and industrial markets and the reasons behind consumers' decisions to purchase or not to purchase. Information is needed on preferences, levels of information or misinformation, and satisfactions or dislikes of both present and potential consumers. We also need to know consumer attitudes toward the old and new product forms of agricultural commodities and their competitors, and probable trends in the consumption of farm products. We need to know the relationship between agricultural and nonagricultural products and the relationship of one agricultural commodity to another in consumers' patterns of use. Producer and industry groups and marketing agencies consider this information essential in planning programs to maintain and expand markets for agricultural commodities which, in turn, increase returns to growers.

USDA PROGRAM

The Special Surveys Branch of the Standards and Research Division conducts applied research on representative samples of industrial, institutional, or household consumers and potential consumers, in local, regional, or national marketing areas. Such research may be conducted to determine: attitudes, preferences, buying practices, and use habits with respect to various agricultural commodities and their specific attributes; the role of competitive products, and acceptance of new or improved products.

The Special Surveys Branch also conducts laboratory and field experiments in sensory discrimination of different qualities of a product. These studies ordinarily relate discrimination to preferences and attitudes as they influence purchases in order to assess the standards of quality, packaging, etc., which are needed to satisfy consumer demands.

In addition to surveys of consumer preferences and discrimination, the Special Surveys Branch also provides consultants and conducts special studies, upon request, for other agencies within the Department of Agriculture or within the Federal Government, when survey methods can be usefully applied to the evaluation of programs, services, or regulatory procedures of interest to the requesting agencies.

The work of the Branch is carried out in cooperation with other Federal governmental agencies, divisions within the Department of Agriculture, State Experiment Stations, Departments of Agriculture, and land grant colleges, agricultural producer, processor, and distributor groups. Closely supervised contracts with private research firms are used for nationwide surveys; studies in selected areas are usually conducted by the Washington staff, with the assistance of locally recruited personnel.

The Branch maintains all of its research scientists, who are trained in social psychology and other social sciences, in Washington, D.C., which is headquarters for all of the survey work whether it is conducted under contract or directly by the Branch.

The Federal scientific effort devoted to research in this area during the past year totaled 7.0 professional man-years under regular program funds; of this total, 6.8 professional man-years were devoted to consumer preference research and .2 professional man-years were devoted to quality discrimination research. An additional 2.2 professional man-years were devoted to research conducted under transfer of funds arrangements.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Agricultural Experiment Stations. The Stations do not report any of their work under this heading. However, they do have a considerable program in the area of consumer buying and use practices and motivation and decision making. This includes some research in preference and quality discrimination. There is a reference to parts of the stations' program in other division reports.

Industry and Other Organizations conduct research in this area, but the research done by individual firms and organizations is almost without exception for their exclusive internal use. There are very few instances in which the findings are made public or made available for government reference. In addition to the research actually initiated and paid for directly by industry, a substantial amount is undertaken in their behalf as part of the service provided by their advertising agencies.

Producer Groups: A number of food producer groups conduct consumer preference work with their own staff and, in addition, contract for research with private marketing firms. To a large extent, this research is limited to food classes such as poultry, dairy products, citrus and deciduous fruits (rather than being directed to individual branded products). This research ranges from a small to national coverage. It includes taste testing for quality differentiation, new product acceptance, and attitudes toward existing products. The producers of agricultural fibers have a small but active research program on quality evaluation and consumer preferences, both household and

industrial, for cotton and for wool. Estimated annual expenditures by these groups are equivalent to approximately 10 professional man-years.

Food Processors: In the livestock industry most of the larger packers have research programs for evaluating the effect of product change and acceptance of new meat products. A sizable number of other food processors have extremely large programs of consumer research. They are engaged in work on new food forms and convenience foods such as cake mixes, canned and frozen fruits and vegetables, deciduous fruits, citrus fruits, soups, dairy products, and alcoholic beverages. Manufacturers of cooking oils and shortenings support sizable consumer research programs with their own staff and also under contract. Manufacturers of dehydrated foods, such as potatoes, are constantly engaged in consumer research on their own and on competitors' products. Estimated annual expenditures are equivalent to approximately 400 man-years.

Processors of Nonfood Products: Large programs are supported by all of the major chemical manufacturers, directed to consumer preference and acceptance of synthetic fibers and blends. The three largest textile mills which represent a major proportion of the fabrics manufactured in the United States support research of this type. All of the large manufacturers of cigarettes do research to find out consumer taste preferences for their product; what blends, filters and packages are most likely to succeed in catching and holding a market. Estimated annual expenditures are equivalent to approximately 250 man-years.

Miscellaneous Groups: There is a smaller but constant amount of research undertaken by magazines and publishing houses for their principal advertisers. A number of the largest retail stores in our major cities study the consumers' reactions to their merchandise and service by conducting interview studies with customers and noncustomers. One of the largest food retailing chains has an active program in quality research which involves taste testing as well as consumer preference. Estimated annual expenditures for research related to agricultural commodities and nonagricultural products in competition with them are equivalent to approximately 20 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Family food habits.

A study of the effect of differences in national background, education, and occupational status of families on their food habits, done in cooperation with the Pennsylvania State University, was completed and a report has been issued by the University. This study was undertaken to ascertain the effect of ethnic and social characteristics of the family on the relative use of meats, dairy products, and certain fruits and vegetables. National background was found to determine to some extent the kinds and amounts of meats used, although this influence appeared to decline among younger families. Families of American background

were more likely to include fruits and fruit juices in their menus than were families of foreign background. Increased education and occupational status resulted in the increased use of fruits, fruit juices, non-leafy green vegetables, and cheese and ice cream, but not in the increased use of whole milk or meats and meats and poultry. (MD 1-23)

Food stamp plan.

The Special Surveys Branch participated in an evaluation of the pilot food stamp program at the request of the Food Distribution Division, AMS, which financed the research. Surveys were conducted in two of the eight pilot areas to determine attitudes about, and reactions to, the food stamp program. Groups interviewed were a cross section of low-income families who were, and also those who were not, participating in the program, moderate and higher-income families in the community, food retailers, and welfare workers. Results indicate general satisfaction with the program on the part of all groups. Retail grocers reported their sales increased. Participating families reported an increase in the amount and quality of the food that they consumed, especially in such products as meat, poultry, milk, eggs, and fresh fruits and vegetables. Welfare workers in the study areas were, in the main, satisfied that the program was doing a better job than existing or prior programs in improving the diet of low-income and needy families. Finally, the results indicated that families of moderate and higher incomes, although not themselves eligible for the program, had received the program with the recognition that low-income families should be enabled to obtain more and better food, and generally approved of the food coupon approach.

Preliminary results of these attitude surveys were included in a report on the food stamp plan which was issued by Agricultural Marketing Service early in 1962. A final report to Agricultural Marketing Service is in preparation. (MD 1-48)

PUBLICATION REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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IMPROVING MARKETING OPERATIONS THROUGH
RESEARCH WITH FARMER COOPERATIVES
Marketing Division, FCS

Problem. Farmers, in marketing their production, face a revolutionary change in terms of market organization and marketing practices. The ever increasing and important supermarkets require large quantities, good quality, and frequent delivery which the small farmer, working alone, or a cooperative, or local firm of limited size cannot supply. Cooperatives must find ways to consolidate volume, either through internal growth, merger, acquisition or federation to help them meet the needs of mass merchandising. Ways must also be found to reduce marketing costs by increasing efficiency through improved operations, better organizations, and more mechanization.

Farmer cooperatives are an important part of the distribution system and represent a major potential for meeting the farmers' marketing problems in the modern distribution system. They are organized and operated to increase farmers' net income. Through cooperatives, farmers seek to increase their bargaining power; obtain needed services at cost; improve the quality of farm products; and obtain a larger share of the consumer's dollar. Cooperatives face many problems in achieving these objectives. Research is needed which will assist marketing cooperatives, as well as other marketing agencies, solve their problems by making available essential factual information and developing practical and useful operating plans and procedures.

USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operations and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The number of Federal professional man-years involved in this work totals 24.8 of which 3.9 are devoted to cooperative marketing of dairy products.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations are devoting 6 man-years to research on cooperative marketing of which 0.6 is devoted to dairy products. The work in Indiana, Wisconsin and Illinois is directed toward studying different aspects of the operation of dairy-marketing cooperatives.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Coordination of marketing.

Analysis of four specific proposals for combining operations involving 12 dairy cooperatives was completed and a fifth one involving 2 cooperatives is now underway. Although the studies indicated that advantages of economies of scale would be gained by farmer members, the major reasons for consolidation were to improve farmers' bargaining position and gain market stability. The studies also indicated that most stumbling blocks to joining together were based on non-economic considerations.

A detailed analysis of the economic feasibility of a coordinated marketing program for cooperatives serving major market centers in Tennessee and Kentucky is underway. Preliminary findings indicate substantial savings to farmers through a coordinated system for assembling and manufacturing reserve milk. The study also points to the need for pooling systems to distribute these savings from coordinated marketing to all farmers equitably.

A study of five artificial breeding associations in Pennsylvania considering merger potentialities was completed. Although the study indicated that advantages of economies of scale and of a wider selection of bulls would be gained by farmer members, the primary point cited was the necessity to centralize management skills in order that all Pennsylvania farmers reap the benefit of a higher order of management know-how to be obtained through a merger of the five associations.

Pooling and pricing.

Case studies of the pooling practices of two dairy associations selling members' milk in a multiple number of Federal Order markets and unregulated markets have been completed. They revealed that cooperatives tend to establish pooling systems that return to members prices competitive with the prevailing prices in the local areas. While repooling procedures may be used to permit all members to share equally in the benefits or burdens from marketing reserve milk, they did not reblend the value of members' Class I sales between markets.

A survey of the pooling status of dairy cooperatives in all Federal Order markets has been completed. Analysis of these data is not yet completed. Preliminary findings point to the important position played by cooperatives. For example, dairy cooperatives sold almost four-fifths of all milk under Federal Order regulation.

Merchandising manufactured products - nonfat dry milk.

A study of marketing methods and experience of cooperatives in selling nonfat dry milk to commercial users was initiated. Data have been obtained from both manufacturers and users. Analysis of data has not yet been completed.

Improving operating methods and efficiency.

A study to develop standards for determining the cooperative character of individual dairy organizations was completed. The publication from this work is designed to help farmers maintain forms of organization and policies of operations of cooperatives that will best serve their needs in obtaining maximum returns and stable markets.

A program for comparing operating costs of manufacturing plants was developed in cooperation with several Midwestern cooperatives. Total costs of manufacturing butter and nonfat dry milk for the cooperatives studied ranged from 42.4 cents to 65.6 cents per hundredweight of milk used. Generally, total costs reflected economies of scale. However, the influence of scale of operation varied with different operating practices.

Four case studies of the organizational structure and operations of dairy cooperatives were completed. These studies indicated a need for changes in organizational structure to enable cooperatives to meet the present complex problems in milk marketing.

One case study was made of the feasibility of establishing a small fluid milk packaging plant. The study indicated that under the existing conditions farmers would receive greater returns from continued sales to existing milk plants.

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ECONOMIC AND STATISTICAL ANALYSIS
Economics and Statistical Analysis Division, ERS

Problem: Adequate and accurate information is needed on supplies, production and consumption of farm products, and the effects these and other factors have on the prices of agricultural commodities. Such information is needed in planning operations for the producers, processors and distributors and also benefits the consumer in selecting his purchases. Similarly, accurate quantitative knowledge of the interrelationships among prices, production and consumption of farm products are needed by Congress and the Administrators of farm programs to effectively evaluate current and future price support and production control programs.

Due to the instability of the prices he receives, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The farmer needs to be provided with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook intelligence and the development of longer range projections of the economic prospects for the principal agricultural commodities.

USDA PROGRAM

This work involves 1.0 professional man-year in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of milk and milk products. These quarterly appraisals are published 6 times a year in the Dairy Situation, quarterly in the Demand & Price Situation, and the National Food Situation. A comprehensive analysis of the dairy situation is presented at the Annual Outlook Conference. Outlook appraisals are frequently presented at regional or State outlook meetings, at meetings of farm organizations, and to various agricultural industry groups. Special analyses are made from time to time on the probable effect of proposed programs on the production-utilization balance of milk and milk products. Basic statistical series are maintained, improved and published for general uses in statistical and economic analysis.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

All state experiment stations are engaged in price research to fulfill the needs of farmers, handlers, and processors for information necessary for intelligent production and marketing decisions. The USDA provides much of the basic and background information but more geographic specifics and more detailed analysis is often requested of the experiment stations.

A few private colleges and organizations are engaged in price research and may give attention to agricultural products from time to time.

A substantial number of private organizations--including manufacturers of food and fiber products, private commodity analysis, banks and investment houses--are engaged in commodity outlook work similar to that carried on by USDA. This work, however, frequently relates to shorter time periods than those covered by the Department's outlook appraisals, is predominately for private use, and not available to the public.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Commodity Situation and Outlook Analysis.

Milk production rose significantly in 1961, reflecting two successive increases in the level of price supports and a sliding-off in beef prices from the 1959 level. In 1962 the rate of increase slowed and was reversed for several months due to poor pasture conditions and a drop in price supports. Consumption of dairy products from commercial outlets was significantly lower than in 1960 in both 1961 and 1962. This decline in commercial consumption, together with the higher production, led to sharply higher Government purchases for price support and sharply higher Government donations of butter and nonfat dry milk to institutions and needy persons. Stocks of butter and nonfat dry milk in Government hands rose very high and, though pushed with vigor, disposal - particularly of butter - fell steadily behind acquisitions.

In the August 1962 Dairy Situation, a mid-year analysis of the 1962 production and utilization of milk was made in order to afford the dairy industry an early comprehensive view of conditions. The analysis indicated that the commercial market for manufactured dairy products was lagging behind 1961, because the industry was carrying stocks at lower levels than a year earlier, and because consumption of manufactured dairy products had fallen. The decline in the commercial market for dairy products contributed more than increased milk production to the rise in CCC purchases.

The reversal of the 1960-61 rise in milk production was appraised in the same issue. The analysis indicated that milk production is likely to turn upward again in late 1962.

The mounting surplus of dairy products led to several special analyses, published as special articles in the Dairy Situation. These include an analysis of CCC expenditures for dairy price support, which indicated the sharply rising costs of dairy price supports in 1962 and analyzed the causes of the rise. With

acquisitions exceeding disposals, it became evident that the industry needed more information on disposal problems, so the disposition of dairy products under P. L. 480 was analyzed in the June 1962 Dairy Situation, and an analysis was made of the movement of dairy products into consumption through the experimental Food Stamp Plan. This latter study indicated that the Food Stamp Plan would tend to increase consumption of the higher-valued dairy products but decrease consumption of butter and nonfat dry milk.

In 1962, Dairy Statistics through 1960, Statistical Bulletin No. 303, was published, bringing to date the former statistical bulletin in this series and adding new series, particularly on the Federal Market Order Program. This bulletin brings together from many sources a collection of economic statistics relating to the dairy industry, including most of the series in frequent use.

The increase among States in the regulation of dairy product prices led to a survey of State agencies concerned with regulating fluid milk pricing and a study of State laws to revise and extend work done in 1957 and 1959. Findings were brought together in a concise and comprehensive statement of the power and activities of States in regulating fluid milk prices. Together with a summary of Federal regulations, this was published both as a special article in the Dairy Situation, and as an ERS report.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Commodity Situation and Outlook Analysis

Bluestone, Herman. October 1962. Milk outlets--the changing pattern. Agricultural Situation.

Mathis, A. G. Dairy Situation. Published 6 times a year.
ERS, USDA, Washington, D. C.

Mathis, A. G. June 1962. Disposition of dairy products under P. L. 480. Dairy Situation.

Mathis, A. G. June 1962. Continued Story: milk sales up, cream sales down. Dairy Situation.

Dairy Statistics through 1961. 1962. ERS Statistical Bulletin No. 303.

V. NUTRITION AND CONSUMER-USE RESEARCH

Consumer and Food Economics Research Division, ARS

Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help carry out the Department's responsibility to advise on the quantity and variety of foods that will assure maximum benefit and satisfaction to consumers, continuous research is essential on the nutritional requirements of persons of all age groups, and on the nutrient and other inherent values of foods and how to conserve or enhance those values in household preparation and processing. Periodic examinations of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective nutrition education. Such information provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to good production, distribution, and use.

USDA PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care, and preservation; (3) surveys of kinds, amounts, and costs of feeds consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition education programs.

The research is carried out by two divisions of the Agricultural Research Service--the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done in Washington, D. C., and at Beltsville, Md.; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas totals 61.1 man-years. It is estimated that approximately 4.9 man-years is concerned with studies related to dairy products.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and micro-organisms concerned with defining human requirements for nutrients and foods are not reported

on a commodity basis, though some of the work is applicable to this report. This basic nutrition research is described on a nutrient basis in the report for the Food and Nutrition Advisory Committee. The total Federal effort is 29.5 professional man-years.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Station research in 1961 included 22.4 professional man-years devoted to studies of the inherent properties of foods and of their household use; 17.6 to analyses of a variety of foods for vitamins, various lipid and protein components, and minerals; and 2.7 to studies of food consumption and dietary levels of households and of food management practices. Although the State work has not been reported on a commodity basis, some of the above research is applicable to this report.

Industry and other organizations such as universities and professional organizations are estimated to devote about 36 man-years to research on the preparation of materials for nutrition education, surveys of diets of individuals, and studies of functional properties and stability of food and of their specific nutrient contents. Limited work is done on the amount and structure of nutrients in foods and on compiling food composition data. Again, some of this work is applicable to this report.

REPORT OF PROGRESS OF USDA AND COOPERATIVE PROGRAMS

A. Nutritive Values of Foods.

1. Tables of Food Composition. Data review has been completed for a revised edition of Agriculture Handbook No. 8, "Composition of Foods... Raw, Processed, Prepared." This edition will have nearly 2,500 food items as compared with 751 items of the preceding edition, and upwards of 45,000 separate compositional values. For many foods, data will be provided for different forms--raw, canned, frozen, milled, dried, instant, dietetic, etc. The new publication will have, in addition to other constituents, data for protein, fat, carbohydrate, five vitamins (vitamin A, niacin, riboflavin, thiamine, ascorbic acid), six minerals (calcium, phosphorus, iron, sodium, potassium, magnesium). Explanatory notes for foods and nutrients will be added for users of the tables. Information on cholesterol and fatty acids will also be included.

Composition data for about 100 items of milk and predominantly milk products will be included in the revision of Handbook 8. In addition to cows' milk at both 3.5 and 3.9 percent fat, data will be included for goat, reindeer, and human milk. The list of cheeses will be expanded to 16 and will include 3 processed cheeses and 2 types of cottage cheese. A number of baby foods and soups which contain varying

proportions of milk products will be included as well as several mixed dishes containing milk products, such as cheese fondue and various beverages.

2. Vitamin Analyses. Values more representative of the vitamin B₆ content of foods now may be obtained by use of a method recently developed at Beltsville, Maryland. Separation by column chromatography of the three forms of vitamin B₆ naturally occurring in foods permit each form to be assayed individually. Values derived from these data for total vitamin B₆ approximate closely values obtained from rat bioassay.

Research is in progress to combine a number of steps in the determination of various B-vitamins in order to facilitate their simultaneous analyses, permit complete characterization of the B-vitamins in foods and to determine their overall distribution in the food supply.

Dairy products, including fluid milk products such as buttermilk, yogurt, condensed, evaporated and pasteurized whole milk and certain cheeses such as cream, Cheddar, cottage and Roquefort contained less than 1 microgram of vitamin B₁₂ per 100 grams. Camembert and Limburger cheeses had 1 to 3 micrograms per 100 grams and non-fat dry milk was found to average 3.6 micrograms of vitamin B₁₂ per 100 grams. These data were published and these studies have been terminated.

The vitamin B₆ value for non-fat dry milk solids as determined by rat bioassay was 3.2 as compared to 4.1 micrograms per gram by the microbiological assay for pyridoxine, pyridoxal and pyridoxamine. Sixty-three percent of the vitamin B₆ was pyridoxal and 34 percent pyridoxamine. The vitamin B₆ components of various dairy products are being determined.

The vitamin B₆ in fresh milk was determined as part of cooperative studies with the Division of Radiological Health, U. S. Public Health Service, on the effect of the process for the removal of strontium 90 on the milk nutrients. Removal of Sr 90 by a similarly prepared ion exchange resin, Dowex 50, as used for the chromatographic separation of vitamin B₆ components, might also remove vitamin B₆. Tests on a large sample processed for Sr 90 removal showed no significant loss of vitamin B₆.

The control or untreated sample of homogenized fresh milk showed in micrograms per gram: 0.02 pyridoxine, 0.29 pyridoxal and 0.08 pyridoxamine, and a total vitamin B₆ value of 0.39. The treated sample showed: pyridoxine, 0.01, pyridoxal 0.25, pyridoxamine 0.07, a total of 0.33.

3. Mineral Analyses. Mineral elements in homogenized fresh milk were determined as part of cooperative studies with the Division of Radio-logical Health, U. S. Public Health Service on the effect of the process for the removal of strontium 90. The process required an adjustment of pH. It was possible that the Dowex 50 column could remove minerals other than strontium. Analyses were made on the untreated or control sample as well as on the processed sample.

The only change in mineral element content due to the process was an increase in potassium, which almost doubled because of potassium hydroxide used in adjusting the pH back to that of normal milk.

Foods were assayed for mineral element content using the emission spectograph for determinations of aluminum, boron, calcium, copper, iron, magnesium, manganese and phosphorus, and the flame photometer for the determinations of sodium and potassium.

B. Food Properties Related to Quality and Consumer Use.

1. Milk. The interchangeability of different forms of milk in standard formulas for baked products and cooked sauces was determined. White sauce made with whole milk, both fresh and dry, thickened more as it cooled than did sauces made with other forms of milk. Evaporated milk made the thickest sauce, and fresh skim milk and nonfat dry milk the thinnest. In biscuit making, nonfat forms of milk moistened flour more readily than did others. For equivalent tenderness, biscuits require smaller measures of fresh whole, fresh skim and reconstituted nonfat dry milk than of fresh buttermilk, diluted evaporated milk, or reconstituted dry whole milk.

2. Convenience foods. Several convenience foods containing cheese have been included in a study of the comparative cost in terms of serving yield, preparation time and nutritive value of different market forms of food. The research was carried out at Beltsville, Maryland, in cooperation with the Economic Research Service. A report is being prepared on this study.

C. Food Economics and Diet Appraisal.

1. Food Consumption and Dietary Levels. Information on the nutritive value of the food consumption of households based on the 1955 survey data has been summarized in Report No. 16 of the 1955 Household Food Consumption Survey series. Average family food supplies for a week in 1955 were sufficient to provide more than the National Research Council's recommended allowances for calories and eight nutrients for which values were calculated. However, many households (48 percent) had diets that did not fully meet the allowances in one or more nutrients. Other analyses of survey data show the relation of

family size, the education of the homemaker, and of income to the food consumption of households. Because of interest in information on quantities of foods used by high consumers as well as average consumers estimates were made for some 60 food items of the ninth decile--the figure dividing the highest 10 percent of the consumers from the lowest 90 percent. For the milk group the amount consumed per person in "high consumption" households was about 1.5 times as much as in "average consumption" households. Ratios for many separate food items were higher--for example, processed milk was nearly 9 times as much as the average.

Two surveys were conducted cooperatively with the Marketing Research Division, Economic Research Service, in Detroit, Michigan, and Fayette County, Pennsylvania, to provide evidence on the extent to which food consumption is increased and diets improved as a result of the Food Stamp Program.

A report of the food consumption and dietary levels of a group of older, low-income households in Rochester, New York, is in preparation.

Work is being undertaken on food consumption and nutritive content of diets of individuals. A systematic review and summarization of quantities of food consumed is being made through a cooperative agreement with the Minnesota Agricultural Experiment Station. A similar review of the nutritive content of the diets of individuals is being made by Washington staff.

The nutrient content of the per capita food supply, calculated each year, using data on retail weight quantities of food as developed by the Economic Research Service, provides the only source information on year-to-year changes from 1909 to date.

2. Food Management Practices. Information on the kinds, amount, and nutritive value of foods used and discarded in households has been obtained in a series of small studies. Results will help to evaluate survey data on household food consumption.

A report on household practices in handling and storing of frozen food has been prepared, based on surveys in Baltimore, Maryland, and Indianapolis, Indiana. Households provided information on the length of time frozen food was held in home storage, and the temperature of the compartment in which frozen food was being held at the time of the interview.

3. Development of Food Budgets and Other Basic Data for Food and Nutrition Programs. An important aspect of nutrition research is the interpretation and application of research findings to practical problems of food selection in relation to health. An ongoing program

of work includes assembling and interpreting available information on nutritional needs, food consumption, and nutritional value of foods for use by nutritionists, teachers, health workers, and other leaders concerned with nutrition education programs.

A technical report explaining the development of the food budgets, "Family Food Plans and Food Costs," has been completed and is in press. Another in the series of popular publications on food management has been prepared, "Food for the Young Couple." A publication "Family Food Budgeting...for good meals and good nutrition," designed to help families of all sizes is also being prepared.

Regular pricing of family low-cost, moderate-cost, and liberal food plans is published in Family Economics Review on a quarterly basis for the U. S. average and on an annual basis for the regions and the low-cost food plan for the South. Each plan gives suggested quantities of food that will meet nutritional needs for each of 17 age and sex groups and for women during pregnancy and lactation so that household or population totals may be obtained.

Nutrition Committee News, a bimonthly periodical prepared for members of State nutrition committees and other workers in nutrition education provides a channel for disseminating pertinent information and for reporting nutrition education activities. A Nutrition Education Conference sponsored jointly by USDA through its Nutrition Programs Service and by the Interagency Committee on Nutrition Education was held in Washington, D.C., January 29-31, 1962.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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VI. MARKETING SERVICE AND EDUCATION

EDUCATIONAL PROGRAM IN MARKETING
Cooperative Extension Service

The major function of the Cooperative Extension Service, as stated in the Smith-Lever Act is:

"To aid in diffusing among the people of the United States useful and practical information on subjects relating to agriculture and home economics, and to encourage the application of the same."

This broad charter clearly identifies Extension's function as education. This is not education in the abstract, but education for action. Cooperative Extension work in agriculture and home economics is a partnership undertaking between each State Land-Grant College and the U. S. Department of Agriculture, in co-operation with local governments and local people. Extension provides a unique educational service at three levels of government permitting maximum flexibility and adaptation to local conditions and needs while carrying a fundamental core of purpose, objectives, and focus. In striving to attain these objectives, the guiding principle of all Extension workers has always been "helping people help themselves."

The main thrust of Extension work occurs locally through the efforts of more than 3,000 county extension staffs. These in turn are supported by a State Extension Service and a staff of subject matter specialists, which in turn receives support from the Federal Extension Service in the U. S. Department of Agriculture.

1. Objectives of the Program for Dairy Marketing

The extension educational program in marketing and utilization of milk and dairy products is directed to three objectives:

- (1) To reduce the cost of marketing milk and dairy products
- (2) To expand the market for milk and dairy products
- (3) To help people better understand the dairy marketing system

2. How the Program is Carried Out

In striving to achieve these objectives on an educational basis, the problem approach is utilized. By this procedure, extension dairy marketing specialists are responsible for assisting people through educational means to analyze their situation and define the problem, establish the objective they would hope to achieve, appraise alternative solutions to the problem, and provide the essential information which will enable people to take the action necessary to bring about the desired solution.

Currently, the primary emphasis in education is placed on problems occurring in the marketing system, aimed at increasing the effectiveness and efficiency of marketing at the level of the individual firm as well as improvement of the structure of the system. In extension work with milk producers, emphasis is placed on aggregative marketing decisions such as marketing orders, cooperative marketing organizations, and dairy price policy. In addition, a substantial amount of educational work in dairy technology is underway. This work is directed at helping processors of dairy products understand and apply research on new product development, new uses for existing products, and new or improved processing methods.

3. Problem Areas and Accomplishments

A wide range of problems in dairy marketing has been defined in the 50 states and Puerto Rico in the extension educational program. Approximately 85 economists and 30 technologists and engineers located in the Land-Grant Colleges are directing themselves to working directly with the dairy industry or through county extension personnel in solving these problems. Major areas of attention include: (1) milk pricing, including producer pricing, resale pricing, and price policy; (2) plant mergers and consolidations; (3) milk distribution efficiencies; (4) management of milk processing plants; (5) quality problems in the assembling, processing, and distribution of milk; (6) ice cream processing and merchandising; (7) technology and economics of concentrated milk; and (8) efficiency in milk procurement in fluid and manufacturing plants. The two examples that follow indicate more specifically how educational efforts are used in dealing with dairy marketing problems.

Significant success has been achieved in further consolidation of the dairy marketing industry in Iowa into larger and more efficient plant operations. The number of butter manufacturing plants declined from 299 plants in 1957 to 237 plants in 1960. At the same time the amount of butter manufactured declined only slightly during this period. The average production per plant has increased materially and the trend toward larger more efficient plants is continuing. Much of this consolidation activity must be credited to the educational efforts of dairy marketing and utilization personnel activities. During the past year, direct educational assistance in the form of meetings and field conferences was given to more than 20 dairy processing and marketing organizations in the State. In addition, two out-of-state associations were assisted as part of a joint program with marketing extension specialists from other states. During this past year there were four dairy firm consolidations involving 10 associations in the state. These four consolidations were the outgrowth of assistance provided by the Iowa State Extension Service. Several other consolidations occurred during the year without direct assistance from dairy marketing personnel. However, in most instances the successful consolidation may be in part attributed to the educational work conducted with these organizations in prior years. One group has indicated that without the educational activities conducted by dairy marketing and utilization personnel, such consolidation would not have occurred during the past year. While it is difficult to measure the total impact over time of such consolidations, one measure that can be used is the cost reduction occurring in processing activities in these plants. The total output of the four consolidations affected during the past year is 720 million pounds of milk. A price premium and cost advantage, on the average, of 4 cents per cwt. of milk, which is a reasonable estimate, would result in increased income to Iowa producers and marketing associations of \$288,000.

At the request of several cooperative cheese factories in Wisconsin, an analysis was made on the economics of whey drying. At the present time many Wisconsin cheese plants are either dumping whey or paying to have it hauled away. The analysis considered the cost of transporting raw whey to a central plant and drying the whey into an edible product. An alternative method considered was the condensing of whey at feeder plants and transporting the condensed product to a central plant for drying. Some general conclusions may be drawn from the analysis.

- a. The market for human-grade-dried-whey is extremely limited and very competitive. The present manufacturers of this product are able to supply the market and have an excess for sale as animal feed.
- b. Animal-feed-dried-whey is not a profitable operation, even at higher volumes. The animal feed market has been saturated with product, and the price has barely been above the estimated cost of production. However, even a break-even operation on dried whey would be a better arrangement than that of many Wisconsin cheese factories, who are now paying to have whey hauled away.
- c. In order to have unit processing costs reduced to a point approaching the price of animal-feed-dried-whey, it is necessary that plants have a capacity of at least 1 million pounds of raw whey per day. Operation of plants much below capacity or the operation of smaller plants will result in processing costs that are above the market price.
- d. Fifty miles is about the limit that raw whey can be profitably hauled to a central plant for processing and drying. Beyond 50 miles, it would pay to build feeder stations to remove part of the water before transporting the whey to a central plant.
- e. In summary, plants with sound whey processing and marketing programs can net as much as 5-8 cents per cwt. more than plants which merely "dump" whey. This is almost \$3 million for the state as a whole. A sound whey marketing program is, therefore, of importance in the Wisconsin dairy marketing industry. We are working with plants in attempting to set up such a program.

3. Looking to the Future

The content of educational programs in dairy marketing is in a constant state of change. As one problem is resolved, other problems assume a priority. The problems relative to bulk tank assembly, for example, are far less important than they were in the immediate past, while newer considerations such as pricing milk on a solids-not-fat basis are confronting the dairy industry. The range of opportunities for educational work in dairy marketing is very broad. Our continuing challenge is that of anticipating problem areas in order that the focus of subject matter is adequate to the critical needs in dairy marketing.

As we look to the future, several problem areas within the scope of the three major objectives of educational work will require special emphasis.

- a. High costs associated with wholesale and retail milk distribution represent one significant problem area. Also, inefficiencies in milk procurement associated with route overlap, density of milk pickups, and volume per stop are being investigated. In addition, the economies of scale apparent in the processing of fluid and manufactured dairy products suggest continued emphasis of educational work in merger-consolidation-expansion alternatives.
- b. The declining demand for several fluid and manufactured dairy products dictates the necessity for educational work directed at market expansion. Extension marketing specialists will be concerned with economic innovations such as increased services, integrated processing, chain store operations, and dairy stores. Technological innovations directed to new and modified food uses and industrial uses for milk solids will be a basic element in extension programs. Also, extensive educational work will be directed to consumers on problem areas such as saturated fats, radioactive contamination, and the various quantity-quality regulations.
- c. Steps are being taken to intensify educational work directed at understanding the dairy marketing system. Areas of emphasis will include:
 - (1) The dairy problem, including the price income problem on dairy farms, the surplus and cost-of-surplus problem, and the problem of declining milk consumption will receive primary attention. Alternative solutions to the dairy problem, including commodity purchases, supply-management, and direct payments, will be presented as an integral part of this program.
 - (2) Subject matter on producer milk pricing will continue to receive major attention. Federal and State milk orders, market power, interstate milk shipment, Class I and blend prices, and compensatory payments will be included in the subject matter.

- (3) Subject matter directed to problems of destructive competition will receive increased emphasis. Fair trade practices, resale price control, and price and anti-trust legislation will comprise the relevant subject matter.

Through intensive educational efforts in these several areas, the basis for understanding dairy marketing problems may be achieved on a broader scale, providing the opportunity for rational solution of the problems.

DAIRY STATISTICS PROGRAM
Agricultural Estimates Division, SRS

The purpose of the statistical and other reporting services for agricultural commodities of the Department of Agriculture is to provide accurate, timely, unbiased facts for use in appraising the situation and in making current and long-range plans.

Historically, the statistical reporting service was started 100 years ago to meet the need expressed by farmers to know as much about crop and livestock supplies as the people to whom they sold. Today, this type of information is widely used by farmers, processors, distributors, lending agencies, local, State, and Federal Governmental agencies, and other agricultural interests. With the exception of the Bureau of the Census, in the Department of Commerce, which takes a census of agriculture every 5 years, no governmental agency outside the Department of Agriculture provides any considerable body of official statistics pertaining to agriculture.

The reporting and statistical services include, for a wide range of crop, livestock, and livestock products, current national and State estimates of acreage, inventories, production, livestock slaughter, prices received and paid by producers, value of production and sales, and related information. This service work is cooperative and depends to a large degree on the voluntary reporting of information by farmers and by the businessmen who deal with farmers. These public spirited individuals cooperate with the Department in pooling their information for the common good.

The organizational structure for the statistical program consists of the Agricultural Estimates Division, the Crop Reporting Board, and 43 State statistical field offices in the Statistical Reporting Service, USDA. Within Agricultural Estimates Division are the following statistical branches: Field Crops, Fruits and Vegetables, Livestock and Poultry, Dairy, and Agricultural Prices. For more information, see "Major Statistical Series of the U. S. Department of Agriculture, Volumes 1 and 8, Agricultural Handbook No. 118.

OBJECTIVES OF THE PROGRAM FOR DAIRY STATISTICS

The aim of this reporting service on dairying is to furnish timely, comprehensive statistics by States and for the United States on inventory numbers, production, marketing, shipments, prices, value, cold storage holdings of dairy products and other foods for use of producers, processors, distributors, consumers, and the general public. This involves collecting, compiling, and analyzing data from many sources, such as individual producers, packers, dairy processors, handlers, cooperatives, and warehouses, as well as from State and Federal regulatory agencies.

PROCEDURE FOR CONDUCTING THE PROGRAM

Most of the basic information is collected, analyzed, and estimates are prepared by the State Statisticians. These estimates are reviewed by the Crop Reporting Board and the official estimates adopted. The Board issues releases showing the estimates by States and Regions, and, in turn, the State Statistician issues reports which include supplemental information and details of local interest. In most States, an agency, such as the State Department of Agriculture, or the College of Agriculture, cooperates with the U. S. Department through the office of the State Agricultural Statistician. In these States, local area and county statistics and other special reports are prepared and published supplementing the basic Federal program, which is concerned primarily with State and National estimates.

ACTIVITIES, ACCOMPLISHMENTS, AND NEW DEVELOPMENTS

The established series of reports under this program were continued during the year. Considerable attention has been given to modifying procedures in order to better meet the growing needs for statistical reports and to keep up with the changes that are underway. The demands by farmers, industry groups, government agencies and others for more frequent, more comprehensive, more detailed, and more precise reports have continued. Factors affecting the work are the dynamic changes that characterize the dairy industry including increased importance of sideline production, especially with fluid milk distributors and many factories.

A thorough review was made State-by-State of the milk cow and milk production statistical series and revisions made as needed on the basis of the 1959 Census of Agriculture, information on marketings, assessments, annual State Farm Census data, and related information that became available after the original estimates were published. Revised dairy estimates, 1955-59, were published in April 1961. Estimates of fluid milk and cream consumption in selected markets are now being released annually instead of biennially. A complete directory of refrigerated warehouses was released in November 1962.

The regular statistical reports and special reports issued during the past year are listed under publications. An internal research project was continued during the year for improving methods of data collection, forecasting and preparation of official estimates. Through pilot studies there is continuous effort to improve the service and to increase the accuracy of the estimates. In selected Southern and North Central and Western States, experimental interview surveys are conducted in June and December. The results of these surveys are analyzed and modifications introduced in the operating program as their value is demonstrated.

Another special survey of Italian cheese production, by major types, was made for 1961. These data were then compared with the 1957 annual survey and were published in the 1961 bulletin, "Production of Manufactured Dairy Products".

Last year, the Division discontinued releasing the quarterly publication "Wholesale Grocers' Stocks of Evaporated and Condensed Milk" after making inquiry of all users and finding that there was not sufficient interest in the report.

FUTURE PLANS AND NEEDS

Continuing effort will be made to keep up with changes taking place in the dairy industry insofar as existing facilities permit. Use is being made of Automatic Data Processing systems to speedup the release of the annual manufactured dairy products statistics and the monthly Cold Storage Report. Requests for additional information are being received constantly which it is not possible to meet.

PUBLICATIONS

Listed below are the currently published reports of the Statistical Reporting Service relating to the dairy industry:

Weekly reports

1. Creamery Butter Production
(by regions and U. S.)
2. American Cheese Production
(by regions and U. S.)
3. American Cheese Warehouse Statistics
(receipts by regions and receipts and stocks for Wisconsin)

Monthly reports

4. Milk Production, by States and U. S.
(Includes output per cow 1st. of month by States, percent of cows milked, total milk production, U. S. and selected States, grain fed per cow, dairy pasture condition and special summaries in various issues).

5. Fluid Milk and Cream
(Dealers' buying and home and store prices in about 160 markets; sales and receipts in over 70 Federal and State areas.)
6. Production of Creamery Butter and Cheese
(Butter and American cheese by States and U.S.; miscellaneous or foreign-type cheese, U.S. only)
7. Evaporated, Condensed, and Dry Milk
(Production, selling prices, stocks and shipments, nationally, and condensery paying prices for milk by States).
8. Production of Ice Cream and Related Frozen Products
(by States and U. S.)
9. Production of Cottage Cheese, curd and creamed
(U. S. only)
10. Milk Prices Paid by Creameries and Cheese Plants
(Butter and American cheese, by States; other cheese types, U. S. only).
11. Cold Storage
(All foods, including dairy products, under refrigeration in public, private, and semi-private warehouses).

Annual reports

12. Milk Production and Dairy Products
(Annual statistical summary by States or U. S.)
13. Milk -- Production, Disposition, and Income
(by States and U. S.)
14. Fluid Milk and Cream Consumption
(by selected marketing areas, May Fluid Milk and Cream Report).
15. Regional Cold Storage Holdings Summary
(March) All foods, including dairy products.
16. Production of Manufactured Dairy Products
(Complete enumeration of all plants and products by States and U. S.).

